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REPORT ON QUALITY OF INTERSTATE WATERS: MAHONING RIVER, OHIO - PENNSYLVANIA

Public Health Service
Chicago, Illinois

January 1965

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REPORT ON

QUALITY OF INTERSTATE WATERS

MAHONING RIVER

OHIO - PENNSYLVANIA

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Public Health Service, Region V

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SUMMARY AND CONCLUSIONS

1. On the basis of reports, surveys, or studies, having reason to believe that pollution from sources of wastes along the Mahoning River in Ohio may be endangering the health or welfare of persons in Pennsylvania, the Secretary of Health, Education, and Welfare called a Conference of the States of Ohio and Pennsylvania, the Ohio River Valley Water Sanitation Commission, and the Department of Health, Education, and Welfare, on interstate pollution of the Mahoning River, to be held in Youngstown, Ohio, on February 16, 1965.

2. The area covered in this report encompasses the Mahoning River from Warren through Youngstown, Ohio, across the Ohio-Pennsylvania State line to its mouth, the Shenango River from Jamestown, Pennsylvania, to its confluence with the Mahoning to form the Beaver River, and the Beaver from this confluence to Beaver Falls, Pennsylvania.

This area is one of the most highly industrialized of the Nation, with emphasis on the processing of various metallic products. Of these, steel production predominates, with nearly 10 percent of the national capacity in the area.

3. Water uses revolve largely around industrial needs. Upstream reservoirs, owned or operated by Youngstown, the Mahoning Valley Sanitary District, the State of Pennsylvania, and the Federal Government

control flows principally to ensure adequate continuous water supplies to industries and municipalities, to lower temperatures of industrially heated streams, and to flush away the wastes of industries and municipalities. It is only near the lower end of the Beaver River that the main stream is used for municipal water supply and for recreation, such as boating, water skiing, and fishing.

4. Municipalities discharge sewage, most of it after some degree of treatment, to the streams. Most of the towns and cities along the Mahoning and Beaver rivers provide only primary treatment, which removes between about 30 and 50 percent of the bacteria, oxygen-demanding constituents and suspended solids. Most of those on the Shenango provide secondary treatment, which removes about 90 percent of the pollutional constituents.

The total sewered population is about 467,000. The bacteria are reduced by treatment an estimated 59 percent, leaving bacteria equivalent to those in untreated sewage from about 184,000 persons to reach the streams. About 78 percent of the bacterial load is discharged to the Mahoning River in Ohio, and 22 percent to the Shenango and Beaver rivers in Pennsylvania. About 71 percent of the oxygen demand is discharged in Ohio and 29 percent in Pennsylvania.

5. In Ohio, attempts to obtain data on industrial wastes from the Ohio Department of Health, ORSANCO, and the plants themselves were unsuccessful, with the exception of a few of the smaller plants that provided information when visited. Ohio law prohibits the Department of Health from releasing information on industrial wastes without

permission by the industries. In Pennsylvania, data on industrial wastes in the files of the State Department of Health were made available. Without data on Ohio industries, however, a fair and equitable appraisal of relative contributions to the pollution of the river system cannot be made. A detailed study of the industrial waste streams and the rivers will be necessary to establish relative responsibilities.

Despite this handicap, however, a general knowledge of locations, types, and sizes of plants, combined with data available from various stream studies and reports, provides an adequate basis to establish that interstate pollution exists and to indicate the areas in which the pollutional materials are discharged.

The metal processing industries, with steel mills predominating, discharge a variety of waste materials that damage water quality and interfere with water uses. The principal industrial area is along the Mahoning River in Ohio, from Warren to Lowellville, just above the State line. A secondary industrial concentration is in the Sharpsville-Sharon area of Pennsylvania on the Shenango River. Other more or less isolated plants are scattered throughout the rest of the watershed.

Industrial waste constituents that damage water quality are oxygen-demanding materials, strong acids, lime or limestone, phenols and other taste-producing materials, iron, manganese, ammonia, cyanides, oil and greases, and suspended solids. Heat in cooling water discharges cause direct damages and intensify damages by other causes.

6. The Mahoning River has been abandoned as a source of municipal water supply because of pollution. In the reach from Warren, Ohio,

to its mouth in Pennsylvania, it has been rendered unsuitable for this use by bacterial pollution from sewage, and by toxic industrial wastes, such as cyanides and metals, by taste-producing wastes, such as phenols and oils, and by suspended solids, ammonia, iron, manganese, acidity, hardness, and heat, which render the water difficult and expensive to treat or undesirable for consumption and use after treatment. Fluoride concentrations would pose the threat of mottled tooth enamel to children who drank the water.

These effects are modified by dilution by the Shenango River, and by natural purification in the Beaver River, but some of them persist to Beaver Falls, where bacterial pollution, taste and odor, oil, ammonia, iron and manganese have been found to be excessive,and difficult and expensive to control by treatment.

The gross and variable pollution of the Beaver River at Beaver Falls, Pennsylvania, poses a continuous challenge to those responsible for using this river as a source for production of a safe and palatable municipal water supply. Unusual treatment measures, such as abnormal chlorination and extensive use of chlorine dioxide, potassium permanganate, and activated carbon, are required. Annual chlorine applications, averaging between 8 and 9 milligrams per liter, and a daily application up to 60 mg/l, are among the highest chlorine requirements at water plants in the United States. The occurrence of sudden changes in chlorine requirements in excess of 10 mg/l requires unusual care to insure production of a safe water. Either human error or equipment failure could result in an unsafe or unpalatable water.

7. Tangible economic damages attributed to pollution include $9,000 per year due to increased cost of chemicals used at the two Beaver Fallls Municipal Authority's water plants, and $20,000 per year due to increased use of soap, synthetic detergents, and other cleansers by consumers.

Intangible damages attributable to pollution include increased fuel consumption due to scaling of boiler and hot water tanks, adverse effects on plumbing, and increased costs of additional treatment required for water used by certain commercial establishments.

8. While the Mahoning River is extensively used as a source of industrial water supply in the reach from Warren to the State line, it can not be considered a satisfactory source for many industrial uses. Most of the characteristics that render the water unsuitable for municipal uses would interfere with certain types of industrial uses. The specific problems that undoubtedly are encountered in existing industrial uses can be ascertained only from the plants using the water.

9. From Warren to its mouth, the Mahoning River is virtually destroyed as a recreational stream. Oil and grease coat its surface and discolor its banks, suspended solids destroy its clarity, sludge covers its bed, and oil clings to tree limbs and bushes. Oxygen-demanding materials, acids, cyanides, ammonia, suspended solids, and sludge deposits, iron and manganese, and heat have practically eliminated its fish, and the aquatic organisms on which they feed. Bacterial pollution renders it hazardous to any who might swim in it, and even

to those who might contact its waters incidentally in boating or fishing.

The bacterial hazard and oil film, somewhat reduced, persist in the Beaver River to Beaver Falls. Effects of other materials on fish and aquatic organisms persist in the upper reaches of the Beaver, and conditions improve only as the river approaches Beaver Falls, where aquatic organisms increase and a catchable fish population occurs. It is in this same reach that boating and water skiing are noted, even though some health hazard is involved in such uses.

10. Sewage and industrial wastes discharged to the Shenango River in Pennsylvania contribute to some degree to the adverse effects described in the Beaver River. The Shenango below Sharon is covered with an oily film, its aquatic organism and fish population is reduced, and it undoubtedly carries some of the characteristic wastes from metal processing operations that are carried by the Mahoning. In the absence of detailed industrial waste information and more complete stream data, it is not possible to specify the relative contributions of the two streams to the degradation of the Beaver River. The known distribution of industry, and the limited stream data available, however, identify the Mahoning River as a contributor and, in all probability the major contributor, of harmful wastes.

11. Partially treated sewage and industrial wastes discharged to the interstate waters of the Mahoning River in Ohio cause pollution that endangers the health or welfare of persons in Pennsylvania, and therefore are subject to abatement under provisions of the Federal Water Pollution Control Act, as amended (33 U.S.C. 466 et seq.).

INTRODUCTION

On the basis of reports, surveys, or studies, having reason to believe that pollution from sources in Ohio was endangering the health or welfare of persons in Pennsylvania, and in accordance with Section 8 of the Federal Water Pollution Control Act, as amended (33 U.S.C. 466 et seq.), the Secretary of Health, Education, and Welfare called a Conference of the States of Ohio and Pennsylvania, the Ohio River Valley Water Sanitation Commission, and the Department of Health, Education, and Welfare, on interstate pollution of the Mahoning River, to be held in Youngstown, Ohio, on February 16, 1965.

This report on interstate pollution of the waters of the Mahoning and Beaver river system is based on previous reports; official records of the Public Health Service; information furnished by interested State and local agencies, individuals, and industries; and data obtained by the Public Health Service from limited field studies conducted during January, 1965, involving biological aspects, industrial water supplies and wastes, municipal water supply, and selected indicators of stream quality.

The cooperation of the numerous agencies and individuals is gratefully acknowledged.

THE AREA

The Mahoning River drains an area of 1,131 square miles (See Figure I), of which 1,076 square miles are in northeastern Ohio, and 55 square miles in western Pennsylvania. The headwaters of the Mahoning River are in the vicinity of Alliance, Ohio. It then flows northeasterly to Warren, Ohio, where it continues southeasterly through Youngstown, Ohio, crossing the State line about nine miles downstream from Youngstown. The Mahoning River flows through Pennsylvania for a distance of about 12 miles, before it joins the Shenango River near New Castle, Pennsylvania, to form the Beaver River. The Beaver River then flows in a southerly direction about 20 miles, before it becomes confluent with the Ohio River at Rochester, Pennsylvania.

Little Yankee Creek receives wastes from metal processing industries in Hubbard, Ohio, just north of Youngstown, and flows northeast across the Ohio-Pennsylvania State line to join the Shenango River southwest of Sharon, Pennsylvania. Also southwest of Sharon the Shenango River, carrying the wastes from the Sharpsville-Sharon area, loops across the Pennsylvania-Ohio State line into Ohio for about one-half mile and then returns to Pennsylvania.

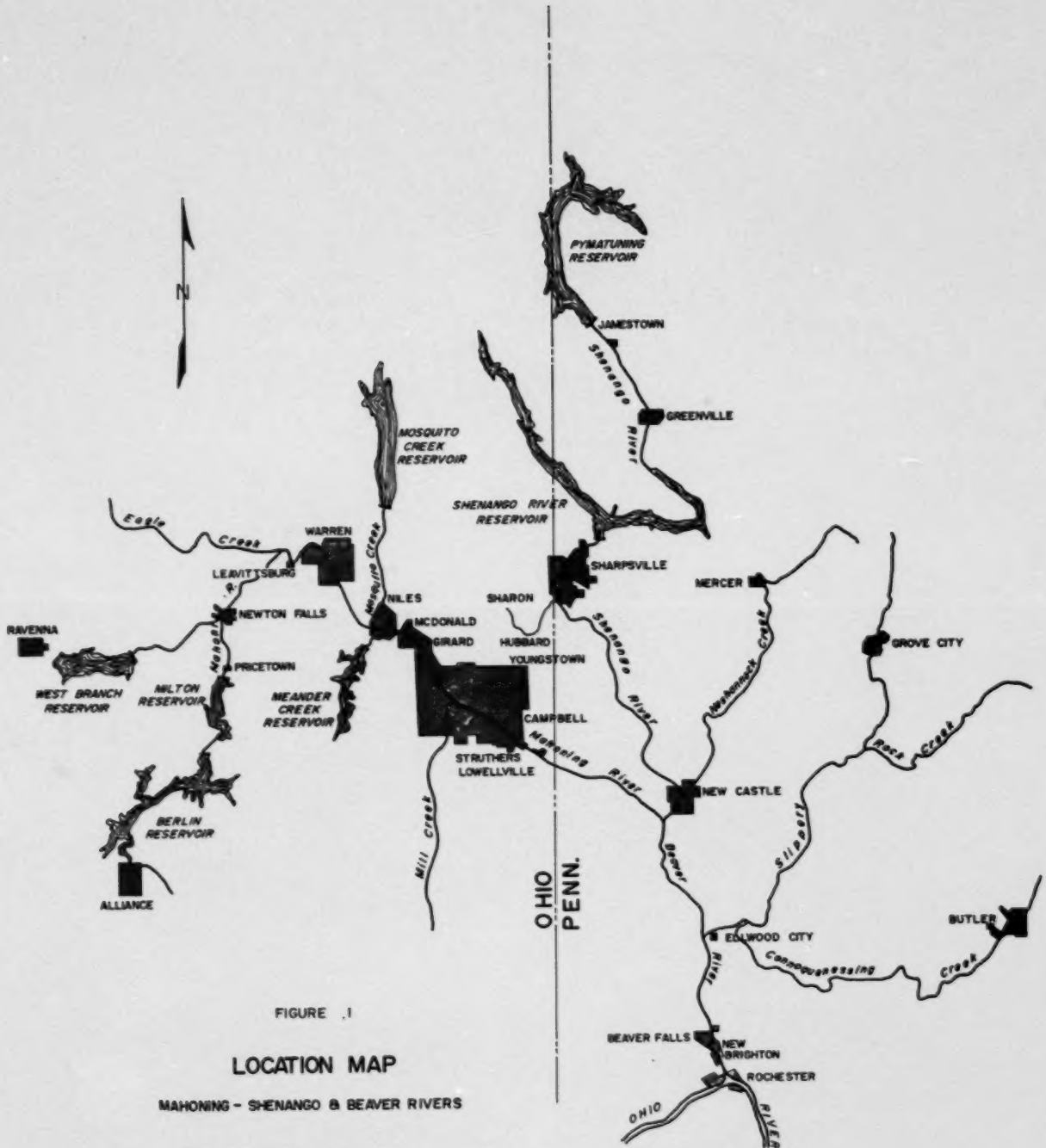


FIGURE .1

LOCATION MAP

MAHONING - SHENANGO & BEAVER RIVERS

0 4 8 12

MILES

8-a

The Beaver River drainage area, including the tributary areas of the Mahoning and Shenango rivers, is about 3,145 square miles. The Shenango River drains 1,080 square miles, 285 square miles of which are in Ohio, and 795 square miles in Pennsylvania.

The economy of the region is heavily dependent on manufacturing. The percentage of total employment engaged in the manufacture of primary metals is 12 times greater than the national average. Much of the industry is located along the 25-mile reach of Mahoning River between Warren and Lowellville, Ohio. Other important industrial areas are in and near Sharon and New Castle, Pennsylvania.

WATER USES

Reservoirs

As shown on Table 1, several major reservoirs now operating or under construction are located in the Beaver River Basin. The Corps of Engineers has constructed four of these reservoirs, including Berlin, Mosquito Creek, and West Branch reservoirs, in the Mahoning River Watershed, and Shenango River Reservoir in the Shenango River Basin. These four reservoirs provide over 466,000 acre-feet of storage capacity for flood control, water supply, and streamflow regulation. Flow regulation in the Mahoning River has been designed to meet water quality objectives which are highly complicated by the many uses made of the stream, such as the assurance of industrial water supply, for the control of the temperature of industrial supplies, and for the disposal of municipal and industrial wastes.

Milton Reservoir, located on the Mahoning River, was constructed in 1917 by the City of Youngstown and private interests for flow regulation purposes. This reservoir is now operated in coordination with Berlin Reservoir. Meander Creek Reservoir, on a tributary of the Mahoning River, was constructed by the Mahoning Valley Sanitary District in 1931. This reservoir serves as a source of municipal water to communities served by the sanitary district, including Youngstown, Niles, and other communities in this general area. Arrangements have been made to augment the capacity of this reservoir by diverting water

Table 1

Major Storage Reservoirs
Beaver-Mahoning and Grand River Basins

Reservoir	Date Completed year	Location of Dam	Drainage Area square miles	Storage Capacity, acre-feet			Owner or Operator
				Water Supply	Flow Regulation	Total[a]	
Milton	1917	Mahoning River 5 miles above Newton Falls	276	-	-	29,150	City of Youngstown
Berlin	1943	Mahoning River 35 miles above Warren	87	19,400	58,800	91,200	Corps of Engineers
Pymatuning	1933	Shenango River 1.6 miles above Jamestown	158	19,400	159,900	198,200	Commonwealth of Pennsylvania
Meander Creek	1931	Meander Creek 2 miles above mouth	249	30,800	-	32,400	Mahoning Valley Sanitary District
Mosquito Creek	1944	Mosquito Creek 9 miles above mouth	97	11,000	69,400	104,100	Corps of Engineers
West Branch	Under Construction	West Branch 11 miles above mouth	81	-	52,900	78,700	Corps of Engineers
Shenango River	Under Construction	Shenango River 2 miles above Sharpsville	589	-	30,000	192,400	Corps of Engineers
		Total	1,537	80,600	371,000	726,150	

[a]Includes storage for silt, flood control, and other purposes.

10-a

by pipeline from Berlin Reservoir. Mosquito Creek Reservoir, located on Mosquito Creek, a tributary of the Mahoning River, serves as a source of water for the city of Warren, Ohio. Pymatuning Reservoir was developed by Pennsylvania in 1933. It is located in the headwaters of the Shenango River, upstream of the Shenango River Reservoir. This reservoir serves a number of purposes, and is used intensely for recreation.

There are several important smaller reservoirs in the Basin, such as Mill Creek, Yellow Creek, Dry Run and others that are operated for water supply purposes.

Municipal Water Supply

The Mahoning River was used as a source of municipal water for the Warren-Niles-Youngstown area for many years, but was abandoned because of gross pollution, and the increased demand for water. Supplies were developed in upland tributaries that were relatively free of pollution.

On the lower Beaver River, the Beaver Falls Municipal Authority and New Brighton water plants use water pumped from pools formed by lowhead dams and serve an estimated 65,000 persons. Water supplies from this source are difficult and costly to treat. High iron and manganese concentrations, oils, phenol-like and other taste and odor producing substances, are some of the causes of water treatment complications.

Industrial Water Supplies

Industries between Warren and Lowellville, Ohio, use large quantities of Mahoning River water. The largest use is for industrial

cooling purposes, primarily in the production of basic iron and steel in this highly developed industrial complex. Average industrial use of Mahoning River water by the principal firms has been reported to be in excess of 1,500 mgd during peak production periods. As the average annual flow of the Mahoning River at Youngstown is less than half this quantity, it is obvious that reuse of streamflow is often very high.

Recreation

Water-oriented recreation activities have increased rapidly across the nation, especially near centers of pollution. The great recreational potential of the Mahoning and Beaver rivers for pursuits such as boating, swimming, and fishing, has not been realized, under present circumstances because of the high degree of pollution that exists in these waters.

The main stem of the Mahoning River, from Warren, Ohio, to the confluence with the Shenango River in Pennsylvania, is so polluted that it is practically uninhabitable for fish. Thick black sludge deposits, floating solids, greases, and oils are prevalent throughout, causing the stream to be unusable for recreational activities.

Farther downstream on the Beaver River, and in the general vicinity of the Beaver Falls area, there is a limited fishery for carp, bullheads, and suckers, and the river recently has been stocked with black crappies, bass, and channel catfish. This is indication of downstream improvement in the stream quality to support fish, although the sanitary quality remains poor. Despite this fact, some boating and aquatic sports take place in the pools created by the dams in this area.

SOURCES OF MUNICIPAL WASTES

A summary of the principal municipal waste discharges to the stream between Warren, Ohio, and the mouth of the Beaver River is given in Table 2. The bacterial content and biochemical oxygen demand of waste discharges are expressed as population equivalents; one population equivalent is that quantity of a constituent that would be contained in the daily untreated sewage produced by one person.

Bacteria

Coliform bacteria that originate in the intestines of warm-blooded animals, including man, are normally used as indicators of bacterial pollution and accompanying health hazards. The estimated bacterial loadings discharged from principal municipal sources are shown on Table 2 and Figure II.

All of the principal municipal sources of sewage receive some treatment at this time, or have treatment facilities under construction. The total sewered population of the principal sources of municipal wastes in the study area is about 467,000 and the waste treatment facilities have a capability of reducing the bacterial content of the sewage about 61 percent (assuming that the Youngstown primary waste treatment plant, now being constructed, is operating). Of the estimated total waste load of 184,000 bacterial population equivalents (BPE) originating in the study area, 78 percent is discharged in Ohio and 22 percent in Pennsylvania.

Table 2
Estimated Characteristics of Municipal Wastes

Jurisdiction	State	Receiving Stream	Type of Treatment	1960 Population	Population Served	POPULATION EQUIVALENTS Bacteria Number	Bacteria % of Total	Oxygen Demand Number	Oxygen Demand % of Total	River Miles
Warren	Ohio	Mahoning River	Primary	59,648	53,000(1)	26,500	17.8	47,400	20.5	21-35.3
Niles	Ohio	Mahoning River	Primary	19,545	26,000(1)	13,000	8.7	11,900	5.2	21-29.5
McDonald	Ohio	Mahoning River	Primary	2,727	2,730(1)	1,300	0.9	1,000	0.4	21-27.8
Girard	Ohio	Mahoning River	Primary	12,997	12,995(2)	6,500	4.4	8,500	3.7	21-23.6
Mahoning Co. Austintown S.D.	Ohio		Youngstown	(1400)	(1400)(2)					
Mahoning Co. Boardman S. D.	Ohio	Mahoning River	Secondary	(12,250)	12,250(2)	3,000	2.0	1,800	0.8	
Mahoning Co. Pine Hollow S.D.	Ohio		Youngstown	(180)(2)						
Youngstown	Ohio	Mahoning River	Primary	166,689	168,270(2)	84,100	56.4	109,400	47.3	21-19.1
Campbell	Ohio	Mahoning River	Primary	13,406	14,400(1)	7,200	4.8	7,900	3.4	21-15.3
Poland	Ohio		Struthers	2,766	(2,765)(2)					
Struthers	Ohio	Mahoning River	Primary & Cl.	15,631	18,400(3)	1,800	1.2	12,000	5.2	21-13.9
Lowellville	Ohio	Mahoning River	Primary	2,055	2,200(1)	1,100	0.7	470	0.2	21-11.4
Union Twp.	Pa.		New Castle	7,161	(x) (2)					
New Castle	Pa.	Mahoning River	Primary & Cl.	44,790	47,000(2)	4,700	3.1	30,500	13.3	21-3
Mahoning River Total				361,245	357,245	149,200	100	230,870	100	
	Ohio			309,294		144,500	96.8	200,370	86.8	
	Pa.			51,951		4,700	3.2	30,500	13.2	
Hubbard	Ohio	L. Yankee Creek	Secondary	7,137	7,135(2)	700	12.4	1,500	10.2	21-28.6
Sharon	Pa.	Shenango River	Secondary	25,267	25,270(3)	500	8.8	3,800	25.8	21-25
Farrell	Pa.	Shenango River	Secondary	13,793	15,000(2)	3,700	65.5	8,000	54.4	21-23
Hickory Twp.	Pa.	Shenango River	Secondary	12,635	4,000(2)	100	1.8	600	4.2	21-21
West Middlesex	Pa.	Shenango River	Primary	1,301	1,300(2)	650	11.5	800	5.4	21-12
Shenango River Total				60,133	52,705	5,650	100	14,700	100	
	Ohio			7,137		700	12.4	1,500	10.2	
	Pa.			52,996		4,950	87.6	13,200	89.8	

13-2

Table 2 (Cont.)

Estimated Characteristics of Municipal Wastes

Jurisdiction	State	Receiving Stream	Type of Treatment	1960 Population	Population Served	POPULATION EQUIVALENTS Bacteria Number	Bacteria % of Total	Oxygen Demand Number	Oxygen Demand % of Total	River Miles
Taylor Twp.	Pa.	Beaver River	Primary	1,402	900(2)	450	1.6	600	1.6	21
Wampum	Pa.	Beaver River	Primary	1,085	700(2)	350	1.2	450	1.2	14
Ellwood City	Pa.	Connoquenessing Cr.	Primary	12,413	14,000(2)	7,000	24.5	9,100	24.5	12-2
Koppel	Pa.	Beaver River	Primary	1,389	1,390(3)	700	2.5	900	2.5	11
Chippewa Twp.	Pa.	Brady River	Primary	6,051	75(2)	40	0.1	50	0.1	7-2
Dawson Ridge	Pa.	Beaver River	Primary	550	40(2)	20	0.1	30	0.1	6
Patterson Hts.	Pa.		Beaver Falls	817	(x) (2)					
Patterson Twp.	Pa.		Beaver Falls	2,930	(x) (2)					
West Mayfield	Pa.		Beaver Falls	2,201	(x) (2)					
White Twp.	Pa.		Beaver Falls	1,437	(550)(2)					
Beaver Falls	Pa.	Beaver River	Primary	16,240	30,000(2)	15,000	52.5	19,500	52.5	5
New Brighton	Pa.	Beaver River	Primary	8,397	10,000(2)	5,000	17.5	6,500	17.5	2
Total Beaver River (All in Pa.)				54,911	57,105	28,560	100	37,130	100	
Total for Basin				476,289	467,055	184,010		283,300		
	Ohio			309,294	65%	144,500	78	200,370	71	
	Pa.			166,995	35%	39,510	22	82,430	29	

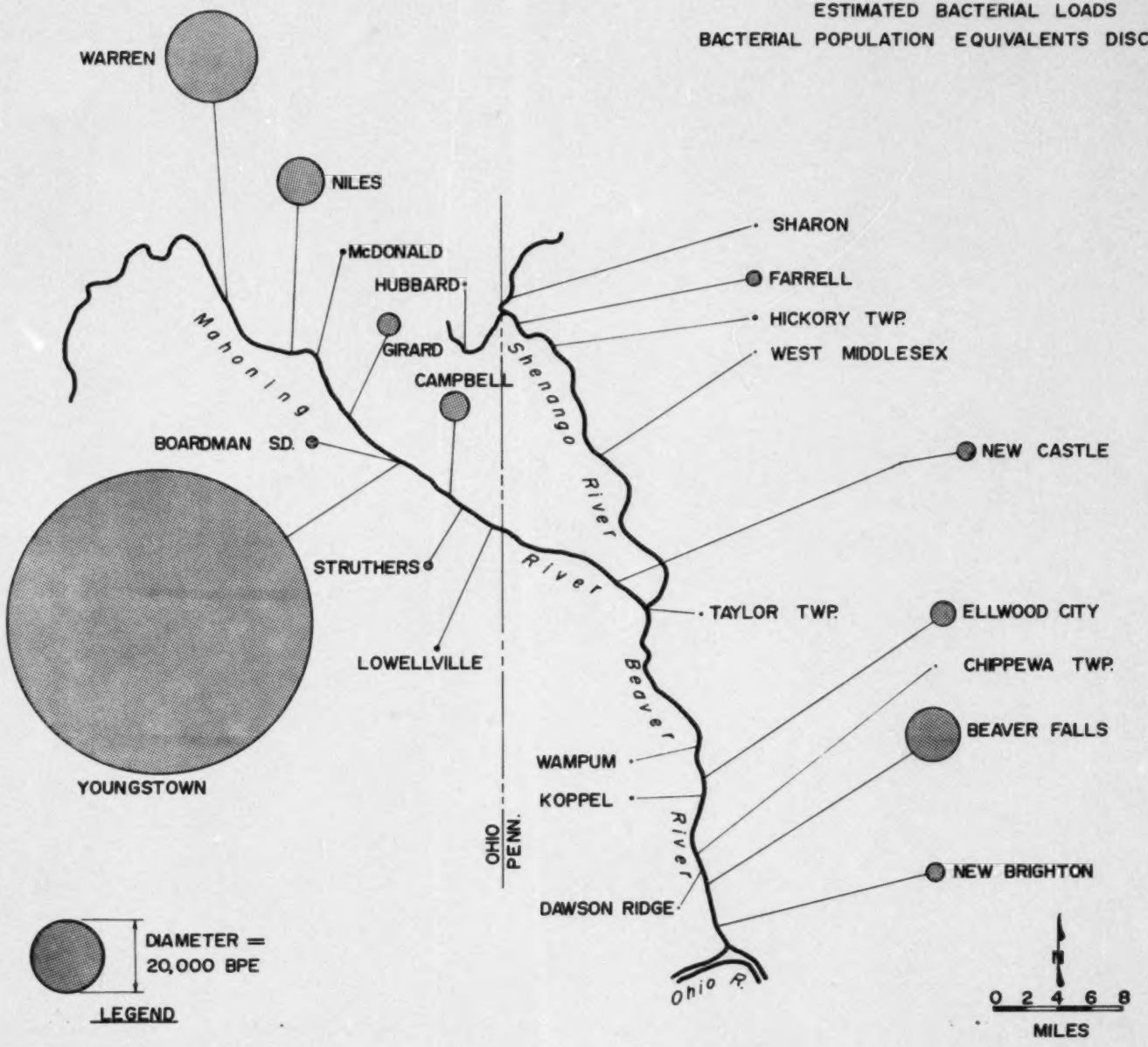
13-a

(1) From Sewage Treatment Plant Operation and Maintenance Questionnaire, Reg. V.
(2) From 1962 Inventory of Municipal Waste Facilities.
(3) Estimated from 1960 population figures.

FIGURE II

ESTIMATED BACTERIAL LOADS

BACTERIAL POPULATION EQUIVALENTS DISCHARGED



13-C

Biochemical Oxygen Demand

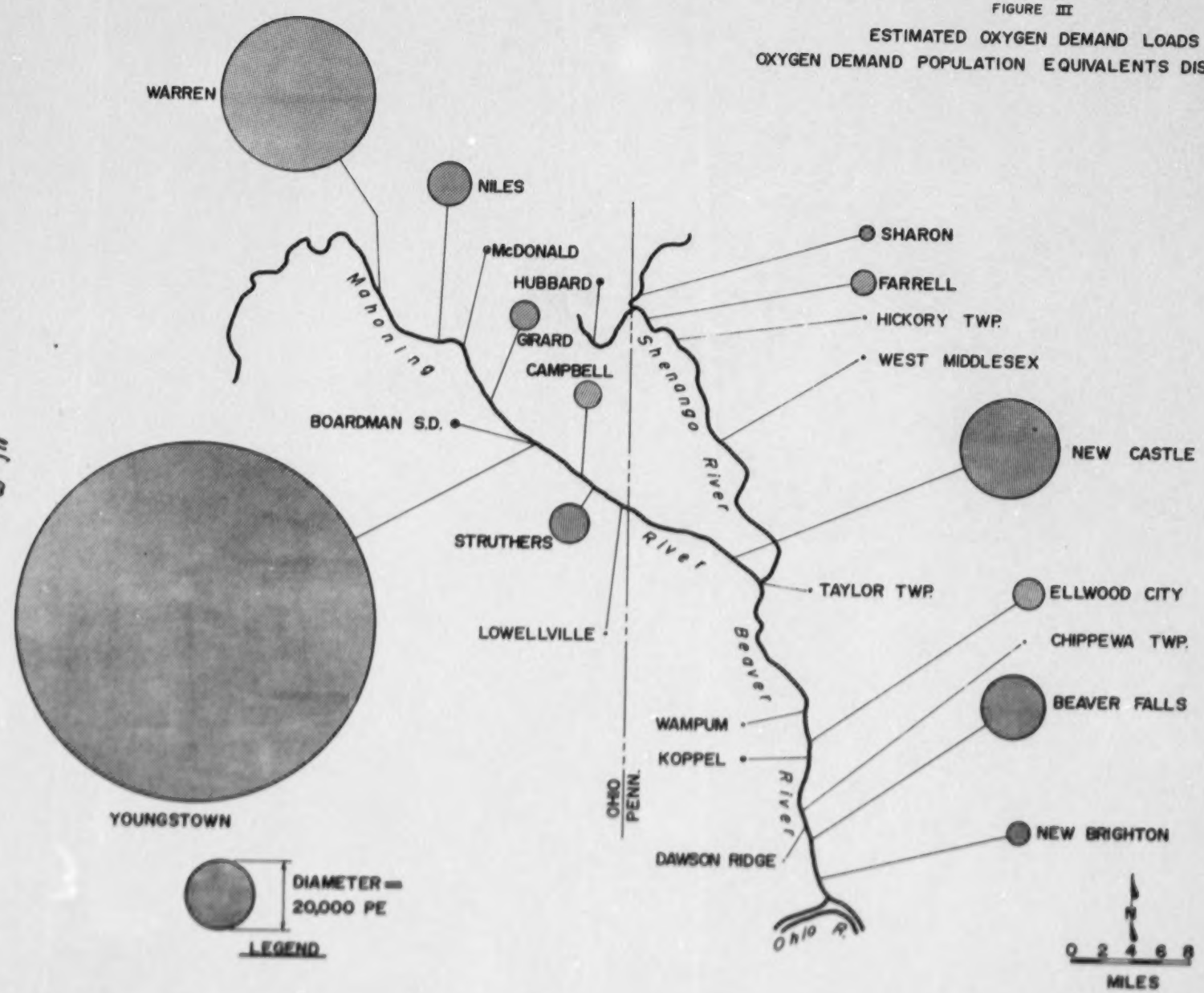
Oxygen-demanding organic waste loads, discharged from municipal systems to the Mahoning River by communities from Warren, Ohio, to the Pennsylvania State line, are estimated to have a population equivalent of 200,400 after treatment. This constitutes about 72 percent of the total organic wastes discharged in the study area via municipal waste outfalls (see Figure III and Table 2).

A stream that is excessively depleted of oxygen, because of overloading with oxygen-demanding wastes will not support a good fish population and if the dissolved oxygen is totally depleted, the decomposition of organic matter will produce offensive odors.

FIGURE III

ESTIMATED OXYGEN DEMAND LOADS

OXYGEN DEMAND POPULATION EQUIVALENTS DISCHARGED



SOURCES OF INDUSTRIAL WASTES

Mahoning River

The streams under consideration drain one of the most highly industrialized areas in the United States. Some 10 percent of this country's steel production is concentrated in the Mahoning River Basin. Production of iron and steel, and fabrication of various steel products overshadow all other manufacturing in this area.

Cognizance is taken of the waste control measures and water pollution abatement programs that have been developed at the steel mills operating in the Warren-Youngstown area. However, residual steel mill wastes discharged to the Mahoning River are still cause for concern.

The principal industries discharging waste to the Mahoning River and its tributaries are listed in Table 3. This tabulated information indicates the types of wastes and the approximate volumes. Effluent data for most of these industries were not available.

Steel is produced from iron ore at the following mills:

Community	Name
Warren, Ohio	Republic Steel Co.
McDonald, Ohio	U. S. Steel Corp.
Youngstown, Ohio	Youngstown Sheet & Tube Co.
	Republic Steel Co.
Campbell, Ohio	Youngstown Sheet & Tube Co.

Table 3

Data on Sources of Industrial Pollution
Mahoning River & Tributaries

Name & Location	Process	Production	Water Use, mgd	Source of Water	Waste Volume, mgd Cooling	Waste Volume, mgd Industrial	Treatment	Discharge to	Oil #/day	Cr^{+6} #/day	P #/day	Temp. °F	Oil gal/day	Acid #/day	NH3 #/day	Phenol #/day	Fe #/day	Susp. Sol. #/day	BOD #/day	Source of Data
Warren, Ohio																				
1. American Welding & Mfg. Co.	Welding & Assembly	X	0.10	Mahoning R. & Wells	0.10		None	Dunker Cr.	-	-	-	X	X	-	-	-	-	X	-	1
2. Copperweld Steel Co. Aristoloy Div.	Prod. of Carbon & Alloy Steels from Scrap	35,000 tons/mo.	38.53	Mahoning R. & Warren	38.5	0.03	Cooling - Settling Ind. - Neut. & Settling	Mahoning R.	-	-	-	X	X	X	-	-	X	X	X	Visit
3. Dunean Rubber Co.	Mfg. Tires, Tubes	Max. 2500 Tires/ day	0.18	Wells	0.03	-	None	Mahoning R.	-	-	-	180	-	-	-	-	-	-	X	Visit
4. Pittsburgh Steel Co. Thomas Strip Div.	Cold Rolled Strip Steel	X	1.40	Mahoning R. & Warren	0.38	0.91	Cooling - None Ind. - Ca.Trt.(Alk. Chlor.)	Mahoning R.	M	-	-	X	X	X	-	-	X	X	-	1, 2
5. Republic Steel Corp.	Tin Plate, Hot & Cold Strips & Sheets, Galv. Sheets	X	110.5	Mahoning R. & Warren	74.4	44.9	Cooling - None Ind. - Clarif., Neut. & Settling Pits	Mahoning R.	X	X	X	X	X	X	X	X	X	X	X	1, 2
6. Sharon Steel Corp. Sharon Strapping Div.	Steel Strapping Bl. - Galv. Strip	X	0.12	Warren	0.11	0.0004	Cooling - None Ind. - Controlled Disch.	Red Run	X	X	-	X	X	X	-	-	X	X	-	1
7. Taylor-Winfield Corp.	Welding Machinery & Controls	X	0.057	Warren	0.05	50 g/d	None	Mahoning R.	-	-	-	X	X	-	-	-	-	-	-	1
8. Van Huffel Tube Corp.	Steel Tubing & Rolled Metal Shapes	X	0.07	Warren	0.05	400 g/d	Cooling - None Ind. - Chem. & Flo-tation	Red Run	X	X	-	X	X	X	-	-	X	X	-	1, 2
9. Warren Tool Corp.	Heavy Hand Tools, Railroad Tools	X	0.038	Warren	0.036	-	None	Red Run	-	-	-	X	X	-	-	-	-	-	-	1
Niles, Ohio																				
10. American Welding & Mfg. Co.	Steel Fabrication, Doors, Frames	X	0.037	Niles	0.036		None	Mahoning R.	-	-	-	X	X	-	-	-	-	-	-	1
11. Jones & Laughlin Steel Co. Conduit Div.	Steel Duct & Tubing	114 million ft. tubing & 2 million ft. duct	0.49	Niles	0.48		Alk. Chlor. for CN Destruction	Cr. to Mahoning R.	> 0.49	19	-	X	X	X	-	-	X	X	-	Visit
12. Mahoning Glass Plant Div. O.E. Co.	Glass Parts for Sealed Lamp Beams	X	0.033	Niles	X	No Niles Glass Pits.	None	Mosquito Cr.	-	-	-	X	3	X	-	-	-	X	-	Visit
13. Niles Glass Plant Div. O.E. Co.	Clear & Frosted Glass Envelopes	X	0.43	Niles	X	0.20	Lime Neut. & Settling	Mosquito Cr.	-	-	> 80	X	X	X	X	-	-	X	-	Visit
14. Nat'l Gypsum Co.	Fabr. of Metal Prod. Metal Lath	X	1.44	Niles	1.2	0.04	None	Mahoning R.	-	-	-	X	X	-	-	-	-	-	-	1
15. Nuactive Metals, Inc.	Titanium Bars & Sheets Zirconium Tubing	Ti 400 T/mo. Zr 30-50 T/mo.	1.5	Niles	0.9	0.6 + Batch Dumps	None	Mahoning R.	-	-	12,000-19,000 #/mo in 3-5 Batch Acid Dumps	X	X	1,000 + 3-5 Batch Dump/ mo.	-	-	-	X	X	Visit
16. Republic Steel Corp. Container Div.	Steel Containers	X	0.30	Niles	0.19	0.003	None	Mahoning R.	-	-	-	X	X	X	-	-	X	X	X	1
17. Republic Steel Corp. Rolling Mills	Rolling Mills	X	4.82	Mosquito Cr.	1.79	3.02	Cooling - None Ind. - Lime Neut.	Mahoning R.	-	-	-	X	X	X	-	-	X	X	X	1
18. Valley Fabricators, Inc.	Steel Stampings	X	0.085	Niles	0.085		None	X	-	-	-	X	X	X	-	-	X	X	-	1
McDonald, Ohio																				
19. U. S. Steel Corp. McDonald Mills	Blast Furnace Steel Works & Rolling Mills	X	56.5	Mahoning R. & Municipal	7.0	48.0	Cooling - None Ind. - Scale Pits, Lagoon	Mahoning R.	X	-	X	X	X	X	-	-	X	X	X	1, 2

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Table 3 (Cont.)

Data on Sources of Industrial Pollution
Mahoning River & Tributaries

Name & Location	Process	Production	Water Use, mgd	Source of Water	Waste Volume, mgd		Treatment	Discharge to	CN #/day	Cr^{+6} #/day	F #/day	Temp. °F	Oil gal/day	Acid #/day	Alk #/day	Phenol #/day	Fe #/day	Susp. Sol. #/day	BOD #/day	Source of Data
					Cooling	Industrial														
Youngstown, Ohio																				
20. Allied Chemical Corp.	Coal Tar Oil Fractions & Pitch	X	X	X	-	0.085	Oil Separator	Mahoning R.	-	-	-	X	X	X	-	X	-	X	X	1
21. Pittstamm Steel Co., Inc.	Cold Rolled Sheet, Strip & Bars	X	0.042	Ohio Water Service & Well	0.019	0.019	Cooling - None Ind. - Contr. Disch.	Dry Run	-	-	-	X	X	X	-	-	X	X	-	1, 2
22. Hoover Products, Inc.	Gauss & Toys	X	0.12	City	0.16	-	None	Storm Sewer	-	-	-	X	-	-	-	-	-	-	-	1
23. Kessler Products Co., Inc.	Misc. Plastic Prod.	X	0.13	City	0.13	-	None	Storm Sewer	-	-	-	X	-	-	-	-	-	-	-	1
24. Koppers Co., Inc. Tar Products Div.	Asphalt Felts & Coatings	X	X	X	-	0.1k	Oil Separator	Crab Cr. to Mahoning R.	-	-	-	X	X	-	-	X	-	X	X	Visit
25. MacKenzie Muffler Co.	Auto Parts & Accessories	X	0.01	City	0.16	-	None	Storm Sewer	-	-	-	X	-	-	-	-	-	-	-	1
26. Republic Steel Corp.	Blast Furnaces, Coke Ovens, Steel Works & Rolling Mills	X	238.4	Mahoning R. O.W.S. & City	189.6	49.9	Cooling - None Ind. - Settling Pits	Mahoning R.	X	-	X	X	X	X	X	X	X	X	X	1, 2
27. U. S. Steel Corp. Ohio Steel Works	Blast Furnaces, Steel Works & Rolling Mills	X	139.5	Mahoning R. O.W.S. & City	100.0	39.0	Cooling - None Ind. - Clarifying Dumps, Scale Pits	Mahoning R.	X	-	X	X	X	X	X	X	X	X	X	1, 2
28. Wilhoff Co.	Fab. Metal Products	X	0.019	City & O.W.S.	0.011	0.008	None	Dry Run	-	-	-	X	X	X	-	-	X	X	-	1, 2
29. Youngstown Sheet & Tube Co. Brier Hill Works	Blast Furnaces, Coke Ovens, Steel Works & Rolling Mills	X	64.3	O.W.S. Gired, Yo., Pumping	55.5		None	Mahoning R.	X	-	X	X	X	X	X	X	X	X	X	1, 2
Campbell, Ohio																				
30. Youngstown Sheet & Tube Co.	Blast Furnaces, Coke Ovens, Steel Works & Rolling Mills	X	169.37	O.W.S.	X	X	Settling - Gas Wash Wastes, Coke Quenching, Acid Sludge Recovery	Mahoning R.	X	-	X	X	X	X	X	X	X	X	X	2
Struthers, Ohio																				
31. Youngstown Sheet & Tube Co.	Steel Conduit, Wire, etc.	X	16.3	Mahoning R.	X	X	X	Mahoning R.	X	X	X	X	X	X	-	-	X	X	X	2
Edgbury, Pa.																				
32. American Cyanamid Co.	Nitroglycerin	X	X	Mahoning R.	-	0.000	Neut. of Acid Wash Water	Mahoning R.	-	-	-	-	-	X	-	-	-	X	X	3

Sources of Data:
1. 1960 Industrial Questionnaire, State of Ohio, Department of Natural Resources, Division of Water.
2. Ohio Department of Health. 1958-59 Mahoning-Shenango River Survey Data.
3. Pennsylvania Department of Health, Reg. 3 Office Records.

Notes:
"O.W.S." - Ohio Water Service. A private company supplying water to consumers in the Youngstown-Campbell-Struthers area.
"X" - Constituent likely to occur in waste discharges. No data available.
"-" - Constituent not likely to be present in waste discharges.

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In addition to the steel mills listed above, there are three other large industrial water users. These are:

Community	Name
Warren, Ohio	Copperweld Steel Co.
Niles, Ohio	Republic Steel Corp.
Struthers, Ohio	Youngstown Sheet & Tube Co.

There are a number of satellite industries in the Mahoning River Basin that fabricate steel products. Other types of manufacturing include coal tar products, titanium and zirconium products, rubber goods, and glass lamps.

Based on available information, the total water used by industries discharging wastes directly to the Mahoning River and its tributaries amounts to 820 mgd. It is significant that the nine industrial plants listed above account for 99 percent of this total water use. Review of effluent data for manufacturing plants, other than steel, reveal them to be relative minor sources of industrial wastes. Industrial pollution evidenced by Mahoning River data originates primarily at the steel manufacturing and fabricating plants.

Acid Wastes

The removal of oxide scale from steel prior to further processing is an essential step in the manufacture of many steel products. Such major items as sheets, strip, wire and pipe are descaled by immersion in an acid bath for a short period. This operation is called pickling.

Dissolution of part of the scale and some of the base metal results in depletion of the acid and accumulation of iron scale in the bath; for this reason the solution eventually loses its effectiveness and must be discarded.

Spent pickling solutions and acid rinse waters continue to be major sources of acid discharged to the Mahoning River. Sulfuric acid is generally used for steel pickling, accordingly these discharges are high in dissolved iron salt and sulfates. It has been reported that some of the steel mills treat spent pickle liquor with lime to neutralize free acid. Other mills discharge spent pickle liquor onto slag dumps. Drainage from these neutralizing processes would be expected to be high in magnesium sulfate and calcium sulfate. These sulfate salts contribute undesirable permanent hardness to the Mahoning River waters. Rinse water following pickling operations are a continuing source of acid. The oxygen demand of ferrous sulfate discharged to the Mahoning River may be a significant factor in reducing oxygen levels in this stream.

Hydrofluoric acid and nitric acid are employed by two manufacturing plants in the Niles, Ohio, area. These are recognized as minor sources of acid. These acid wastes are neutralized at one of the plants and a pilot plant for acid recovery is presently being installed at the other plant.

Iron Wastes

Acid wastes from cleaning steel are a major source of iron in solution. Inert iron particles originate in rolling mill scale and in

blast furnace flue gas wash water. It is customary to provide sedimentation facilities for recovery of mill scale and iron ore from the blast furnace flue gas wash water. However, significant quantities of these suspended solids still reach the Mahoning River.

Oil Wastes

Type of bearings and their lubrication in rolling mills are important to water pollution because of oil which may appear in the mill discharge. Information is lacking on the quantities of oil originating at these sources. However, oil slicks on the Mahoning River downstream from some of these rolling mills is evidence of this oil waste.

Phenol Wastes

Phenol originates from the by-product coke plants and the coal tar processing plants which operate in the Warren-Youngstown area. It is understood that concentrated wastes at the by-product plants are used to quench coke. Phenol adsorbed on the coke carries over and appears in the blast furnace flue gas wash water. The Mahoning River data reveal considerably more phenol than can be accounted for from the effluent of the plants processing coal tar. This means that the steel mills continue to discharge significant quantities of phenol.

Cyanide Wastes

By-product coke plants are recognized as a potential source of cyanide wastes. The highest concentration of cyanogen compounds occurs in the gas final cooler water. It is understood that the by-product coke plants operate essentially closed systems. This would mean that

cyanide wastes would be released to the Mahoning River only at times when the water system was out of balance resulting in overflow.

Blast furnace flue gas wash water is another source of cyanide. The cyanide concentrations in these waters are low but the volume is considerable.

There is some metal finishing in the Warren-Youngstown area. Rinse waters from these metal plating departments constitute another source of cyanide wastes.

Heavy Metal Wastes

Metal finishing operations referred to in the Warren-Youngstown area are also a source of heavy metals. One of the plants in the Niles area was reported to discharge some quantities of hexavalent chromium. Such materials are highly pollution in character.

Shenango and Beaver Rivers

The principal industrial activity in the valleys of Beaver River and Shenango River is the production of iron and the fabrication of steel products. There is some electro-plating and sand and gravel washing. The principal industries discharging wastes to the Shenango-Beaver Rivers are listed in Table 4.

Acid and Iron Wastes

Quantities of acid and iron in steel pickling rinse waters are discharged to the Shenango River below the dam of the Shenango Valley

Table 4

Data on Sources of Industrial Pollution
Shenango and Beaver Rivers

Name & Location	Process	Production	Water Use, mgd	Source of Water	Waste Volume, mgd Cooling	Waste Volume, mgd Industrial	Treatment	Discharge to	CN #/day	Cr^{+6} #/day	F #/day	Temp. °F	Oil gal/day	Acid #/day	NH_3 #/day	Phenol #/day	Fe #/day	Susp. Sol. #/day	BOD #/day	Source of Data
Hubbard, Ohio																				
1. General A.M. Transport. Corp.	Heavy Metal Fabr.	X	X			0.04	Oil Separation of Wash Water	Yankee Cr.				X	X							1,2
2. Valley Mould & Iron Co.	Cast Molten Iron	X	X			0.1	Cooling Water, n.t.	Yankee Cr.				X								1,2
3. Youngstown Sheet & Tube Co.	Blast Furnace	X	18		13.	0.18	Furnace Cooling Water, n.t. Gas Scrubber Overflow	Yankee Cr.				X						X		1,2
Jamestown, Pennsylvania																				
4. Klamm, Inc.	Electroplating Parts for Gym Sets	X	X			-	Acid & Alk. Rinses Combined & Discharged Through Lagoon. Zinc Cyanide Wastes are Chlorinated & Precipitated. Chromate Wastes are Reduced & Precipitated.	Shenango R.													3
Kelly, Pennsylvania																				
5. Atlas Sand & Gravel	Sand & Gravel Washing	X	X			0.25	Sedimentation	Little Shenango R.												3
Jamesville, Pennsylvania																				
6. Tennessee Tube	Stainless Steel Tubing	X	X			0.02	HNO_3 & HF Wastes Treated with Lime	Shenango R.						X			X			3
7. Westinghouse Electric Corp.	Etching Transformer Parts	X	X			0.001	Neutralize Acid Wastes	Shenango R.												3
Sharpsville, Pennsylvania																				
8. Shenango, Inc.	Blast Furnace	600 T/day	X			89.0	Gas Scrubber Water Treated by Sedimentation. Isolation for Discharge of CN.	Shenango R.	4 mg/l				X					X		3
Sharon, Pennsylvania																				
9. National Castings Co.	Steel Foundry	X	X			0.216	Sedimentation of Sand Reclamation Waste Water. Furnace Cooling Water does not Require Treatment.	Shenango R.				X				1.3 mg/l			200 mg/l		3
10. Sharon Steel Co.	Blast Furnaces & Steel Mill	70,000 T/mo.				X 14.0 30.0	Acid Rinses not Treated Steelworks not Treated	Shenango R.				X	X	X			X	X		3
11. Sharon Tube Co.	Butt Welded Pipe	X	X			- 0.43	Acid Rinses not treated Cooling Water from Scale Pits not treated	Shenango R.					X	X			X	X		3
12. Westinghouse Electric Corp.	Electroplating of Transformer Parts	X	X			0.12	Neutralize Acid & Caustic Wastes. Complete Chlorination of Cyanide Wastes.	Shenango R.						X			X			3
12a. Sawhill Tubular Prod.(Mercer Pipe Div)	Steel Tubing	9,000 T/mo.	X			-	Secondary Acid Rinses,n.t. Cooling Water, n.t.	Shenango R.					X							3
Mercer, Pennsylvania																				
13. Westaco Co.	Tractor Parts	X	X			0.10	Oil Separation of Oil-bearing Waste Water	Otter Cr.					X							3
New Wilmington, Pennsylvania																				
14. New Wilmington Cheese Co.	Receiving Milk	X	X			Small	Trickling Filter	Little Neshannock												3

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Table 4 (Cont.)

Data on Sources of Industrial Pollution
Shenango & Beaver Rivers

Name & Location	Process	Production	Water Use, mgd	Source of Water	Waste Volume, mgd Cooling	Waste Volume, mgd Industrial	Treatment	Discharge to	CN #/day	Cr^{+6} #/day	F #/day	Temp. °F	Oil gal/day	Acid #/day	Alk #/day	Phenol #/day	Fe #/day	Chem. Sol. #/day	BOD #/day	Source of Data
New Castle, Pennsylvania																				
14. Blair Strip Steel	Steel Rolling Mill	X	X		0.880		Oil Separators on Cooling Water. Acid Wastes Hauled Off Site.	Big Run												3
15. Crane Co.	Cast Iron Foundry	X	X		0.880		None. In violation	Big Run					X					X		3
16. Flowline Co.	Welded Fittings	X	X		0.005		Acid Rinses Not Treated	Big Run						X			X			3
17. Shenango Ceramics	Dinnerware	X	X		0.14		None. In violation	Shenango R.										X		3
18. Universal Needle	Vitrified Sanitary Ware	X	X		0.036		Sedimentation & Chlorination	Shenango R.												3
West Mayfield, Pennsylvania																				
19. Babcock & Wilcox Tube Co.	Tubular Steel Prod.	11,000 T/mo.	X		1.0		Cooling Water Passed Through Oil Separators	Beaver R.												3
						5-10	Acid Rinses Not Treated							X			X			
Beaver Falls, Pennsylvania																				
20. Republic Steel Company	Drawing Steel Bars	7,000 T/mo.	X		0.029		Acid Rinses Not Treated	Beaver R.						X			X			3

Sources of Data:
1. 1960 Industrial Questionnaire. State of Ohio, Department of Natural Resources, Division of Water.
2. Ohio Department of Health. 1958-59 Mahoning-Shenango River Survey Data.
3. Pennsylvania Department of Health, Reg. 3 Office Records.

Notes:
"X" - Constituent likely to occur in waste discharges. No data available.
"-" - Constituent not likely to be present in waste discharges.

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Water Company at Sharon, Pennsylvania. Major sources are Sharon Steel Company, Republic Steel Company, and Babcock and Wilcox Tube Company. Waste pickle liquor is collected and treated off site except at Sharon Steel where it is discharged to hot slag piles. The oxygen demand of ferrous sulfate discharged to the Shenango River is recognized.

One small plant at Greenville, Pennsylvania, neutralizes hydrofluoric acid wastes prior to discharge to the Shenango River.

Cyanides Wastes

There is one recognized source of untreated cyanide-bearing waste water discharged to the Shenango; this is waste water from the blast furnaces at Sharpsville.

Oil Wastes

The cooling water used in rolling mill operations may pick up some oil from oil-lubricated bearings. These cooling waters are discharged to the Shenango River below the dam at Sharon without benefit of oil separation.

Suspended Solids

The cooling waters from rolling mill operations is passed through scale pits for recovery of mill scale but fine material is not completely removed. Additional discharges of suspended solids occur from foundry and ceramic operations.

FEDERAL INSTALLATIONS

Surveys and evaluations of waste disposal practices at all Federal installations throughout the country are being made by the Public Health Service. Installations in the Mahoning River Interstate Area are included in this program.

Table 5 lists the installations in the Mahoning River Basin which discharge wastes to other than municipal sewer systems. The Lordstown Military Reservation and the Youngstown Air Force Base discharge treated wastes to the surface waters in the Mahoning River Interstate Area.

Table 5

WASTE DISPOSAL PRACTICES

AT FEDERAL INSTALLATIONS

IN MAHONING RIVER BASIN

INSTALLATION	DEPT.	RECEIVING STREAM	TYPE TREATMENT	CONTRIB. POP.	VOLUME OF DISCHARGE/DAY	COMMENTS
Ravenna Arsenal	DOD	West Branch Mahoning River	(3) Trickling Filter	300	216,00	On Standby at present
Lordstown Military Reserv.	DOD	Trib. of Mahoning River	Septic tank & Sand filter	125	3,600	Scheduled for shut-down
Wardwell Warehouses	GSA	Ground	Septic tank & Field tile	35	1,000	
Mosquito Creek Dam Control Tower	COE	Mosquito Cr.		3	50	Waste Disposal facilities scheduled for 4/1/65
Berlin Dam Control Tower		Mahoning River		3	50	Waste Disposal facilities scheduled for 4/1/65
Youngstown Air Force Base	DOD	South Fork Spring Run Cr.	Trickling Filter STP	300	70,000	Minor renovations under study
Naval Reserve Training Center	DOD	Ground	Septic tank & Field tile	4	216	

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EFFECTS OF POLLUTION ON WATER QUALITY AND WATER USES

Bacteria

The density of coliform bacteria is used in evaluating bacterial pollution of streams and as a basis for water quality objectives for various water uses. The results of coliform bacteria determinations are expressed in terms of most probable number, or MPN, per 100 milliliters (ml) of water. One hundred ml is a little less than one-half cup. The coliform group usually is designated as total coliform.

A commonly used water quality objective limits average coliform densities to a maximum of 5,000 MPN/100 ml in raw water that is used for a municipal water supply. The same limit is used for water sports that do not involve body contact. Where there is swiming, or other water contact activities, it is common practice to set the upper limit on average coliforms in raw water at 1,000 MPN/100 ml. Where there is suitable water, some of the people who live near the stream, and other who visit the river to enjoy being near water, will swim on an unorganized basis. Probably few venture into the highly polluted Mahoning River, but boating and water contact activity, in the form of water skiing, are known to take place along the lower Beaver River in the vicinity of Beaver Falls, Pennsylvania.

The Pennsylvania State Health Department conducted a water quality study of the lower Mahoning, Shenango, and Beaver rivers from 1959 to

1961. The locations of the sampling stations are shown in Figure IV. Samples were collected on a monthly basis for the two-year period, beginning and ending in the month of September. Table 6 is a summary of the findings. At Station 2, a few miles below the State line in the Mahoning River, the Pennsylvania data indicate that the annual average density of coliform bacteria in the stream was 11,000,000 MPN/100 ml. At Station 8 in the vicinity of the Beaver Falls municipal water intake on the Beaver River, the average coliform density during the two-year study period was reported as 1,100,000 MPN/100 ml. This value, based on a limited number of samples, probably is not so representative of average conditions as are the water plant daily operating records. The bacterial data of the 1964 operating records of the Beaver Falls Municipal Authority, Eastvale Waterworks, included in Table 7, reveal a maximum monthly average of 170,000 MPN/100 ml, and an annual mean of 31,300 MPN/100 ml, or more than six times the previously cited water supply source objective. Such high bacterial densities indicate the existence of a hazard to health to all who come in contact with the water, including water supply consumers in the event of a failure in waterworks equipment or operation.

Dissolved Oxygen

Organic materials in the processes of decomposition in a stream reduce the dissolved oxygen. In addition added heat reduces the capacity of the stream to retain oxygen. The ability of a stream to assimilate waste loads discharged to it without excessive reduction of dissolved

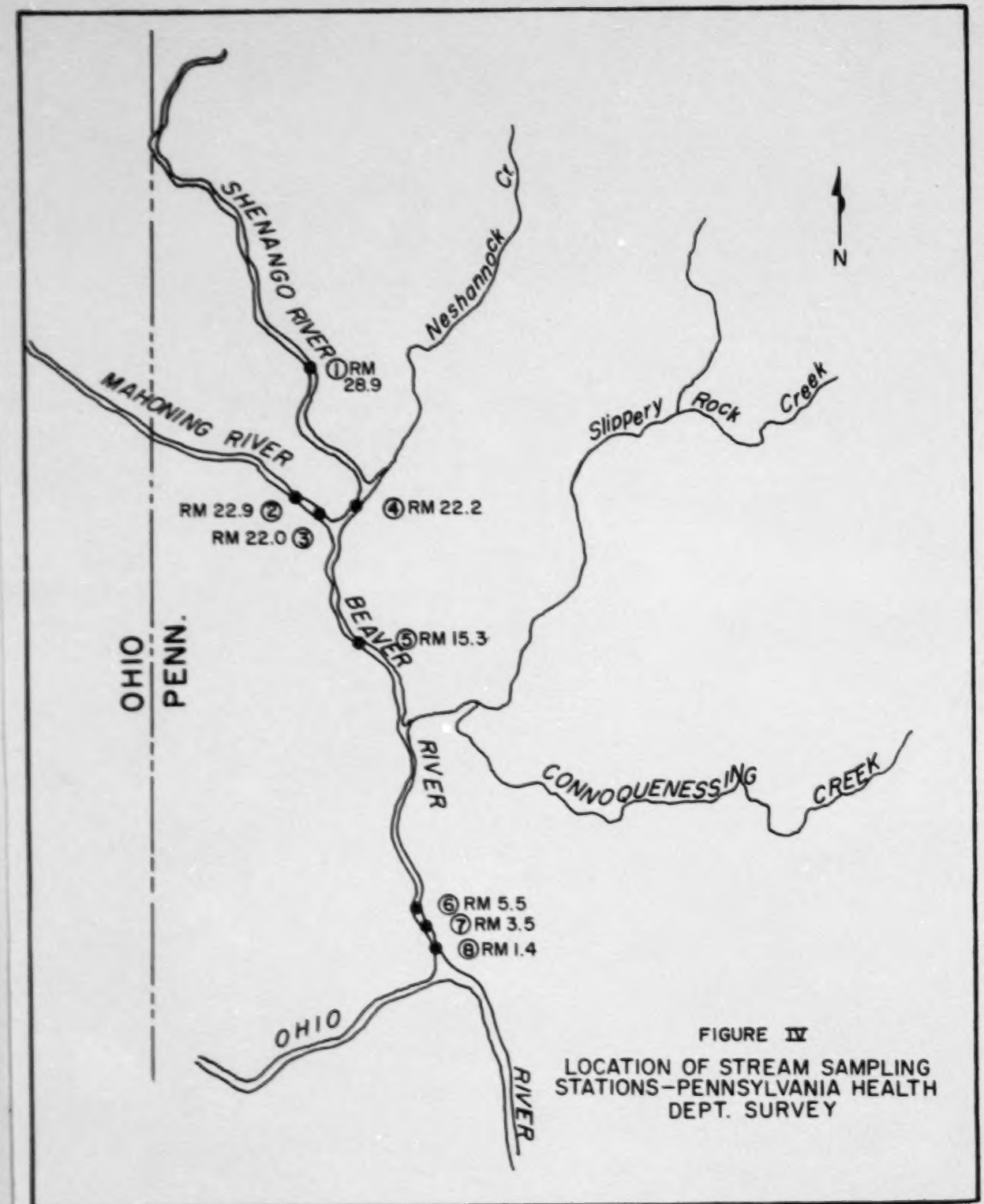

FIGURE IV

LOCATION OF STREAM SAMPLING STATIONS–PENNSYLVANIA HEALTH DEPT. SURVEY

Table 6

Surface Water Quality
Beaver-Mahoning and Shenango Rivers in Pennsylvania
September 1959-September 1961

Station[a]	D.O., mg/l			Coliform, MPN/100 ml		Phenol, mg/l			Alkalinity, mg/l			Total Iron, mg/l		
	Avg.	Max.	Min.	Avg.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.
1	6.6	11.0	4.4			15	100	0	70	120	32	1.6	3.4	0.2
2	4.9	13.8	1.8	11,000,000	230	29	100	0	72	110	44	3.5	16.0	0.2
3	4.8	13.2	1.3	4,600,000	9,300	38	150	0	72	115	44	3.0	20.0	0.3
4	8.3	15.8	4.6			20	100	0	71	125	32	1.2	2.8	0.5
5	5.7	13.3	2.0			20	150	0	69	115	44	1.8	8.4	0.2
6	7.3	13.6	4.1			06	100	0	70	126	32	1.0	3.4	0.2
7	7.8	10.6	4.1			35	300	0	65	110	34	1.5	8.0	0.3
8	8.5	10.9	5.0	1,100,000	230	28	300	0	65	110	32	1.4	5.0	0.2

[a] See Figure IV for location of sampling stations.

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Table 7

Water Quality Data
Beaver River
Eastvale Waterworks - Pennsylvania
1964

		Temp. (F)	Alk. (mg/l)	Turb.	Color	pH	Hard. (mg/l)	Iron (mg/l)	Mang. (mg/l)	Bacteria (MPN/100 ml)	Odor
	Avg.	37	51	35	15	7.1	200	0.28	0.47	13,900	-
Jan.	Max.	43	77	250	32	7.3	246	1.25	1.00	40,000	85
	Min.	34	27	8	7	6.9	130	0.08	0.23	5,400	20
	Avg.	39	46	19	20	7.0	198	0.24	0.36	11,200	-
Feb.	Max.	40	69	40	30	7.3	234	0.52	0.50	34,000	50
	Min.	35	36	11	14	6.9	156	0.11	0.25	3,100	25
	Avg.	42	37	191	25	7.2	133	2.57	0.50	34,800	-
March	Max.	47	68	2000	45	7.3	146	50.00	1.35	105,000	250
	Min.	39	20	12	16	6.9	88	0.12	0.25	7,300	30
	Avg.	52	36	56	28	7.2	131	0.82	0.38	39,600	-
April	Max.	60	46	210	55	7.8	164	2.00	0.80	85,000	200
	Min.	42	27	12	10	7.0	114	0.15	0.25	9,600	30
	Avg.	67	44	23	28	7.2	153	0.87	0.29	33,500	-
May	Max.	74	54	95	45	7.5	202	2.75	0.70	140,000	90
	Min.	60	35	10	15	7.0	120	0.18	0.10	2,000	30
	Avg.	75	50	22	18	7.2	194	0.82	0.37	26,100	-
June	Max.	80	58	90	43	7.5	204	1.12	0.60	65,000	60
	Min.	67	43	8	8	7.1	178	0.32	0.25	6,000	30
	Avg.	82	46	20	19	7.2	188	0.78	0.45	32,600	-
July	Max.	87	66	29	26	7.4	206	1.18	0.90	100,000	60
	Min.	74	32	10	9	7.0	162	0.45	0.20	8,000	30
	Avg.	78	44	19	16	7.1	188	0.74	0.36	43,000	-
Aug.	Max.	82	58	32	31	7.5	202	0.93	0.75	77,000	60
	Min.	73	30	10	8	6.9	180	0.52	0.20	11,000	30
	Avg.	76	37	16	10	7.0	208	0.71	0.33	31,600	-
Sept.	Max.	83	45	23	20	7.3	222	1.25	0.45	55,000	60
	Min.	69	24	10	6	6.7	196	0.18	0,18	10,000	30
	Avg.	63	36	10	9	6.8	221	0.78	0.39	24,800	-
Oct.	Max.	70	51	18	21	6.9	248	1.68	0.52	64,000	50
	Min.	60	23	7	7	6.5	210	0.38	0.30	9,000	25
	Avg.	58	42	11	10	6.8	212	0.69	0.36	15,000	-
Nov.	Max.	63	51	22	18	6.9	230	1.00	0.50	46,000	60
	Min.	45	32	7	7	6.7	188	0.40	0.25	8,000	25
	Avg.	42	39	28	18	6.9	166	1.18	0.46	70,200	-
Dec.	Max.	47	47	155	32	7.2	208	5.00	0.85	170,000	70
	Min.	39	30	10	9	6.8	138	0.28	0.25	8,000	30
Annual Average								0.87	0.39		

23. C

oxygen is an important factor in the ability of the stream to sustain a desirable aquatic life, including fish.

Optimum water water fish production in streams generally requires dissolved oxygen levels of about 5 mg/l. Lower levels of D.O. may support a less desirable fishery and when D.O. levels drop below 3 mg/l, especially in the presence of other contaminants, it is probable that few if any fish can long survive. The States of Ohio and Pennsylvania have established objectives for the minimum dissolved oxygen concentrations which may be allowed in their respective streams. Ohio has established 4 mg/l as the minimum acceptable concentration of D.O. in the Mahoning River above Warren, Ohio. Pennsylvania has selected the same objective for the lower Mahoning, Shenango, and Beavers rivers. Because heat and other pollutants presently discharged to the reach from Warren to Lowellville, Ohio, prevent the maintenance of desirable aquatic life in the stream, Ohio permits a minimum of 3 mg/l from Warren to the Pennsylvania State line. This lower concentration is expected to prevent excessive odor nuisance conditions, even though it may not maintain optimum fish productivity. The Aquatic Life Advisory Committee of the Ohio River Valley Water Sanitation Commission has recommended that "the dissolved oxygen content of water water fish habitats shall not be less than 5 ppm during at least 16 hours of any 24-hour period. It may be less than 5 ppm for a period not to exceed 8 hours within any 24-hour period, but at no time shall the oxygen be less than 3 ppm. To sustain a coarse fish population, the dissolved oxygen concentration may be less than 5 ppm for a

period of not more than 8 hours out of any 24-hour period, but at no tiem shall the concentration be below 2 ppm."

Available stream data from an Ohio report indicate that D.O. levels in the Mahoning River immediately below Warren, Ohio, drop as low as 3.2 mg/l and continue to deplete as the water progresses downstream about 25 miles to Lowellville, At Lowellville, about a mile upstream from the State line, a continuous monitoring station is operated by the U. S. Geological Survey in cooperation with the Ohio River Valley Water Sanitation Commission. For the calendar year of 1964 there were 162 days in which the D.O. dropped below 1 mg/l, and 219 days when the D.O. was less than 2 mg/l. For 63 days the record shows zero D.O., and here the stream is biologically dead, except for the most pollution-tolerant organisms.

No recent D.O. data were available immediately downstream from the State line, but from the previously mentioned 1959-61 Pennsylvania study, D.O. as low as 1.3 mg/l was reported in this vicinity. Above the point of discharge of sewage from Newcastle, Pennsylvania, about 10 miles downstream, the minimum D.O. was 1.3 mg/l also.

Heat

Several public and private concerns have observed water temperatures in the Mahoning River in the Youngstown area for many years. River temperatures are related to air temperatures, streamflow, and the heat added through industrial cooling operations. Heated discharges to the

Mahoning River are a form of pollution, since high river temperatures adversely affect aquatic life, the use of the river for industrial cooling purposes, production costs, and the stream's ability to assimilate organic wastes. The waste assimilative capacity is affected by reducing the dissolved oxygen available at saturation, and increasing the rate at which biochemical oxidation of organic wastes with accompaning D.O. depletion, takes place.

Following extensive study, the Aquatic Life Advisory Committee of the Ohio River Valley Water Sanitation Commission has recommended that "... in order to maintain stream conditions capable of producing an anual harvestable fish crop comparable to that produced in natural waters of the particular area under consideration, waste discharges be so controlled that the temperature of the receiving water:

(1) Shall not be raised above 34°C (93°F) at any place or at any time;

(2) Shall not be raised above 23°C (73°F) at any place or at any time during the months of December through April;

(3) Shall not be raised in streams suitable for trout propagation."

Temperature influences physiologically all the vital processes of fish, including activity, feeding, growth, and reproduction. Higher temperatures often favor the coarse and less desirable fish species. While high temperatures may not prove immediately lethal, they may impair metabolic activity of the fish to such an extent that any additional stress, such as pollution, may increase the adverse effects of temperature, and result in a high level of mortality.

A shift in algal populations has been correlated with the introduction of heated waters; as the temperature increases, the diatoms normally associated with unpolluted streams decrease, with a resultant rise in green algae and finally blue-green algae. These may increase the problem of tastes and odors in water supplies. It has also been found that there is a tolerance limit close to 90°F for a "normal" population structure of bottom dwelling fish food organisms with extensive loss in numbers and diversity of organisms accompanying further temperature rise.

Flow regulation resulting from the operation of Berlin and Mosquito Creek reservoirs has accomplished some reduction in river temperatures. However, the temperatures are still extremely high. West Branch Reservoir when in operation is expected to further reduce the river temperatures in the industrial area along the Mahoning River. It is estimated that this reservoir will effectively reduce the average annual water temperature in the stream at Youngstown by about 4°F.

As shown in Table 8 maximum river temperatures at Lowellville exceeded 93°F during 7 months in 1964, in May through November. The average temperature was 94°F over the 4-month period between June and September. Temperatures in excess of 100°F occurred in June, July, and September. They exceeded 73°F in April and December. Even after the West Branch Reservoir goes into operation, the river temperatures will not be reduced below levels harmful to fish and other aquatic life.

Table 8

Mahoning River Temperatures (F.°)

Lowellville, Ohio

		1964		1963		1962		1961		1960		1959	
		Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
Jan.	Avg.	59	55	58	55	53	51	63	61	-	-	45	42
	Max.	66	63	65	61	59	56	67	66	-	-	62	58
	Min.	45	41	50	50	45	43	57	57	-	-	37	36
Feb.	Avg.	64	61	58	55	53	51	60	58	-	-	42	40
	Max.	69	65	62	60	58	54	67	65	-	-	49	48
	Min.	58	55	49	48	42	40	47	46	-	-	36	35
March	Avg.	51	49	47	45	49	47	50	49	-	-	52	49
	Max.	66	63	61	56	60	60	56	55	-	-	61	61
	Min.	40	39	38	38	41	40	47	47	-	-	42	42
April	Avg.	62	58	70	66	64	61	53	51	-	-	72	69
	Max.	78	72	80	76	82	79	60	59	-	-	84	84
	Min.	45	44	60	56	53	52	47	47	-	-	54	53
May	Avg.	82	78	85	80	83	80	71	69	-	-	88	85
	Max.	94	90	94	86	90	86	82	78	-	-	100	97
	Min.	61	59	73	69	76	72	58	56	-	-	64	61
June	Avg.	94	89	92	87	88	85	82	80	-	-	90	87
	Max.	102	96	99	92	91	88	86	86	-	-	100	97
	Min.	86	84	86	81	81	78	77	74	-	-	78	77
July	Avg.	95	89	90	84	86	83	87	85	87	86	83	82
	Max.	101	96	95	93	90	88	89	87	89	87	91	88
	Min.	89	81	84	78	83	78	82	81	86	85	79	79
Aug.	Avg.	93	89	85	81	89	85	90	88	90	88	79	78
	Max.	99	96	89	85	91	87	93	90	94	91	81	81
	Min.	88	82	81	78	86	83	88	85	86	85	75	75
Sept.	Avg.	94	90	84	79	82	80	92	89	89	87	75	74
	Max.	102	96	89	84	88	87	97	93	94	91	80	79
	Min.	87	87	80	74	75	74	87	84	86	84	70	70
Oct.	Avg.	91	87	82	78	79	76	82	79	80	78	-	-
	Max.	97	93	86	83	87	83	89	86	87	85	-	-
	Min.	87	82	75	72	68	66	77	74	70	67	-	-
Nov.	Avg.	88	83	72	69	68	65	69	67	66	64	-	-
	Max.	94	90	77	74	75	71	80	77	69	68	-	-
	Min.	77	74	61	59	58	57	56	54	63	59	-	-
Dec.	Avg.	72	68	63	60	61	58	58	57	59	57	-	-
	Max.	81	77	69	68	71	68	64	63	64	63	-	-
	Min.	56	53	56	54	52	51	52	52	55	53	-	-

27a

Phenols

Phenols in industrial wastes, especially from coke plants in steel mills, discharged to the Mahoning River present a pollution problem which has particular significance in the use of the Beaver River for municipal water supply. There is evidence of phenol in the stream system below the industrial areas along the Mahoning and Shenango rivers and particularly at the water plants serving the Beaver Falls area. Water containing even very small quantities of phenolic compounds may, after chlorination, carry obnoxious medicinal tastes and odors. Special methods of water treatment, which add to treatment costs, are necessary to combat phenolic tastes.

Commonly used water quality objectives in rivers call for controlling sources of phenolic wastes to assure that phenolic concentrations do not average more than 2 parts per billion, and that no maximum value exceeds 5 ppb. It has been reported that odor-tainting of fish flesh begins to persist at phenol concentrations as low as 15 ppb. The Ohio Health Department has stated that it is believed that known practical methods of phenol control will reduce phenol concentrations in the Mahoning at the State line to not more than 75 ppb.

During the week of January 4, 1965, phenol concentrations as high as 250 to 280 ppb were found in a set of samples collected by the Public Health Service in the Mahoning River, in and below the Warren-Lowellville industrial area along the Mahoning River, and a value of 14.5 ppb near the Beaver Falls water intake.

The 1959 to 1961 Pennsylvania study revealed concentrations as high as 220 ppb, and an average of 38 ppb near the mouth of the Mahoning River, and an average of 28 ppb at Beaver Falls.

During a 16-week period in 1959, virtually the entire steel mill industry in the Beaver River watershed was closed by a strike. Other industries were not substantially affected. Subsequently, the Ohio River Valley Water Sanitation Commission (ORSANCO) compared levels of pollutional constituents in the Mahoning River at Lowellville, and the Beaver River at the Beaver Falls water intake, with levels of the same constituents at these points in earlier years (1952, 1953, and 1957) when the steel mills were in operation. Phenols were among these constituents.

During the 1959 strike, phenols at Lowellville averaged 10 ppb, compared to averages in the range of 5 to 44 ppb in the three previous years, for an overall average of 21 ppb. At Beaver Falls, the average for the 1959 period was 3 ppb.

Taste and Odor

Taste and odor in municipal water supplies may result from many causes. Among these are oils, phenols, naphthalenes, and other organic materials associated with coke by-product production, which may be discharged in wastes from the coke plants normally associated with steel mills.

An indication of the odor potential of water is measured approximately by the threshhold odor (T.O.) determination. This is an involved method and is not often used, unless odor in a municipal water supply presents a problem. The ORSANCO report referred to above included data on threshhold odor of the Beaver Falls raw water. During the 1959 strike, the T.O. number of the raw water was 19. Even this value is relatively high for a clean stream, except in those situations where the odor is caused by algae. During previous years, while the steel mills were operating, the T.O. number ranged from 41 to 202, for an average of 137, which is 7 times the relatively high value that occurred when the steel mills were closed.

To combat tastes and odors, the Beaver Falls water treatment plant is forced to use methods far beyond those of the conventional water treatment plant that obtains water from a source of good quality. These measures require correspondingly increased costs of treatment.

Alkalinity, Acidity and pH

Natural surface waters normally are moderately alkaline, containing calcium bicarbonate and carbonate and other minor alkaline constituents dissolved from the soil and rock through and over which the water flows. The water also contains mildly acidic salts of certain metals, and the mild carbonic acid, which is derived from carbon dioxide in the atmosphere and from decomposing organic matter. The balance between these mild alkalies and acids controls the pH, or hydrogen ion concentration, of the water. At a pH of 7.0 the opposing alkaline and acidic constituents are in exact balance, and the water is said to be neutral. Natural waters rarely are more alkaline than pH 8.5, or more acidic than pH 6.5.

As a result, fish and other aquatic life generally are acclimated to water with pH in the range of 6.5 to 8.5. Drastic variations in pH outside this range can reduce or eliminate desirable aquatic life. A moderately alkaline water is desirable as a source of water supply, since it is less corrosive to concrete and to pumps, piping, and other metallic equipment, than an acidic water. Alkalinity also is essential in the chemical reactions employed in conventional water treatment processes.

Strong acids are used in some industrial processes, such as the sulfuric acid used in large quantities by steel mills. The acid may be discharged untreated, or may be neutralized with lime before discharge. If not neutralized, the acid reduces the natural alkalinity and reduces the pH correspondingly. If all natural alkalinity is

destroyed, the pH drops to about 4.2. Additional waste acid will reduce the pH below even this value.

The Aquatic Life Advisory Committee of ORSANCO has concluded that lethal effects on aquatic life are not produced until the pH is reduced below 5.0, but from the standpoint of productivity, it is best to maintain pH above 6.5. Objectives by the State of Ohio of pH 6.3 and alkalinity of 30 mg/l have been selected as applicable to the Mahoning River at the State line.

It was estimated by ORSANCO in 1959 that 200 tons per day of acid (as equivalent $CaCO_3$) was wasted by the steel mills in the Beaver River watershed.

In 1959 the alkalinity of the Mahoning River at Lowellville averaged 80 mg/l during the steel mill strike, and in the range of 8 to 30 mg/l in the previous 3 years. Alkalinity was adequate at Beaver Falls during all periods, averaging 69 during the strike, compared to about 54 in previous years, but reflected some effect of acid wastes from upstream.

In 1959 the pH averaged 7.3 at Lowellville, compared to a range of 5.9 to 6.1 in the 3 previous years. All pH averages were above 7.0 at Beaver Falls.

The U. S. Geological Survey-ORSANCO monitoring station maintains a continuous record of pH at Lowellville, with occasional gaps because of instrument failure. The record indicates that there were 28 days in 1964 when the pH dropped below 5.0, with a minimum value of 3.6 on 2 days. These acidic conditions would retard and probably destroy aquatic life at and below the State line. The record shows 187 days when the pH was below the Ohio objective of 6.3.

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All average monthly pH values at the Beaver Falls raw water intake were in the range of 6.8 to 7.2 during 1964. The lowest single daily value was 6.5. These values reflect only slightly the effects of the acid wastes discharged upstream. This represents an improvement over the 1952, 1953, and 1957 values in the range of 5.9 to 6.1 reported by ORSANCO, as noted above. Average monthly alkalinities ranged from 36 to 51 mg/l, which is adequate, but below the 80 mg/l in 1959 when the steel mills were closed. Daily minimum values were below 30 mg/l in 4 months, with the lowest being 20 mg/l.

In the results obtained on the single set of samples collected by the Public Health Service during the week of January 4, 1965, the pH ranged from 6.0 to 6.5 in the vicinity of the State line, and was 7.1 at Beaver Falls. Corresponding alkalinities were in the range of 13 to 23 mg/l near the State line, and 26 mg/l at Beaver Falls. The pH at 3 stations in the Niles to Youngstown reach of the river ranged from 3.6 to 4.2, the natural alkalinity at these three stations being totally destroyed by the acid wastes.

Adverse effects of the acid wastes range from severe to moderate in the river system from Warren to Beaver Falls. The pH was low enough to destroy much of the aquatic life in the Mahoning River below Warren, and the alkalinity was below the level desirable in sources of municipal and many industrial water supplies in the Mahoning and in the Beaver River at Beaver Falls.

Hardness

Hardness of water is caused primarily by the salts of calcium and magnesium. As hardness increases, the soap and other detergents necessary for effective cleaning increase. Hard water produces scale in household hot water tanks and in metallic equipment in high temperature industrial processes, which reduces the effectiveness of heating. Hard water can toughen vegetables during cooking. Natural surface waters exhibit various degrees of hardness, depending on the soils and rocks with which they come in contact. The natural alkalinity discussed earlier usually is largely calcium and magnesium carbonate and bicarbonate, which are hardness constituents.

Many heavy industries, including steel mills, use large quantities of limestone, which consists of calcium, and frequently magnesium, carbonate. The principal waste from steel mills that contributes to hardness of the receiving stream is the calcium and magnesium sulfate that result from neutralization of waste acid pickle liquor with limestone or lime.

In the report on river water quality during the 1959 steel mill strike, ORSANCO estimated that the steel mills discharged 90 tons per day of hardness.

The hardness of surface waters varies so widely throughout the country that no limit has been set on hardness in municipal water supplies. Water with hardness less than 125 mg/l usually is considered reasonably soft. In many cases where hardness is in excess of 125 mg/l, special treatment to reduce hardness is considered justified. When

softening is employed, it is common to produce water with a hardness of 70 to 80 mg/l. Industries can use water for various processes that may vary in hardness over a wide range. Most of the required limits fall in the range of 100 to 300 mg/l, but others require hardness less than 100 mg/l. For example, the hardness of water used for cooling and for steel manufacture, which are major uses in the Beaver River Valley, preferably should not exceed 50 mg/l.

At present, data are not available to establish the natural hardness of waters in the Mahoning and Beaver rivers, but it appears that it may be in the range of 100 to 150 mg/l. The hardness of raw water at the Beaver Falls intake averaged 183 mg/l in 1964. The 90 tons per day of hardness estimated by ORSANCO to be added by the steel mills would account for a moderate addition of 15 mg/l of hardness to the average annual flow of the Beaver River at Beaver Falls. ORSANCO data indicated that the hardness was 43 mg/l less during the steel strike than it was during comparable flow periods in previous years when the mills were operating. The increase in hardness concentrations caused by steel mill wastes would be less during higher stream flow periods.

While there undoubtedly are moderate adverse effects of hardness added by industries on municipal and industrial water supplies on the Mahoning and Beaver rivers, presently available data do not allow a full evaluation of effects.

Iron

Iron is relatively insoluble in the presence of oxygen and of the alkalinity within the normal pH range of most natural surface waters. Such waters frequently have low iron concentrations of only a few hundredths to a few tenths of a mg/l. When wastes containing dissolved ferrous iron are discharged to a stream, the iron depletes the D.O. of the stream, adding to the depletion of D.O. by organic wastes. In the process, the iron precipitates and settles to the stream bed, where it coats exposed surfaces, or forms sludge banks that may cover and destroy aquatic life. If the D.O. is totally depleted and if accompanying acid wastes neutralize the alkalinity of the stream, the dissolved iron may remain in solution for many miles downstream and cause difficulties in stream reaches far removed from the point of discharge.

Insoluble forms of iron are relatively inert in water, and usually cause only those difficulties typical of natural silt and other inorganic suspended solids, which destroy the clarity of the water and settle to form bottom deposits.

Even small quantities of dissolved iron in municipal and industrial water supplies can cause problems. It can cause difficulty in water treatment through staining of equipment, especially chlorinators and filter sand. It can cause false readings of chlorine residuals, and thus interfere with the chlorination process that is essential to destroy pathogenic bacteria and protect health. The iron may precipitate as a reddish floc, in the distribution system, causing the familiar

"red water" that flows from some faucets. It stains bathroom fixtures and laundry, turns tea black, and may impart an unpleasant taste to water. It can interfere with a variety of industrial processes. Recommended limits for iron are 0.3 mg/l for domestic water supplies and 0.1 mg/l for many industrial supplies.

Much of the data available on iron in the Mahoning and Beaver rivers does not lend itself to sound interpretation because most of the determinations have been for total iron, both dissolved and in suspension. Since the effects of the two forms on water use are different, it is not possible to evaluate fully the effects on the basis of total iron alone.

For example, the ORSANCO report shows that steel mills in the Beaver River watershed discharged 72 tons per day of dissolved iron and 225 tons per day of iron in suspension. Most of the insoluble iron probably settles to the stream bed with a few miles from the points of discharge. The dissolved iron, on the other hand, undoubtedly carries farther downstream until oxidized.

There is no doubt that the bed of the Mahoning River from Warren to its mouth in Pennsylvania is a depository of large quantities of iron. Reclaiming operations in the Mahoning River at Youngstown are being employed to separate iron deposits from river bottom sludge. Concentrations of iron (chiefly mill scale discharges from steel mills) are apparently great enough to make this operation economical. A hydraulic dredge is employed to remove the deposits from the river, after which the heavy iron materials are settled out and thereby reclaimed. The remaining materials are then re-spread on the river bottom under

surveillance by the Corps of Engineers. The amount of iron recovered is not known, although one report indicated that in one area recovered particles tested from 40 to 52 percent iron. Approximately 4-1/2 river miles have been covered by the recovery operations thus far, and plans call for an additional 2-1/2 miles to be recovered in the near future.

Manganese

Manganese is quite similar to iron in many of its reactions, and most of the above discussion on iron applies to manganese. Manganese probably reacts more slowly than iron, but the discolorations and deposits of various kinds that it can cause are black, and therefore even more objectionable than those caused by iron.

Interferences by manganese with domestic and industrial water uses are even more severe than those by iron, and therefore a lower limit of 0.05 mg/l has been proposed for manganese in both domestic and many industrial supplies.

The ORSANCO report estimated that the steel mills normally discharged 1.8 tons per day of dissolved manganese. The 1964 operating records of the Beaver Falls water treatment plant show that manganese in the raw water ranged from 0.10 to 1.35 mg/l, with an annual average of 0.39 mg/l. This is far above the manganese level of most natural surface waters, which rarely exceed a few hundredths of a mg/l.

Fluorides

It is recognized that fluorides, within optimum limits of 0.7 to 1.2 mg/l in drinking water, are beneficial in protecting the teeth of children against decay, or caries. Continuous ingestion of water containing fluorides much in excess of the upper limit can cause unsightly mottling of teeth.

Fluorides are discharged in the wastes from steel mills, electric lamp manufacture, and zirconium production in the Beaver River Valley. Although a few values reported for the Mahoning River have been in the range of 2.4 to 3.2 mg/l, which is above the desirable limit for drinking water, there is no evidence that the limit has been exceeded at the Beaver Falls water intake, but rather that fluorides have been below the optimum lower limit.

It may be assumed that children drinking water from the Beaver Falls municipal supply may have received some protection of their teeth because of the fluorides discharged upstream. It should be realized, however, that the fluoride concentrations vary considerably and presumably rapidly at times. If the municipality should desire to provide maximum protection of the children's teeth through controlled fluoridation, as is practiced in many cities, the varying concentrations in the raw water would render it difficult to ensure proper dosage of fluorides to achieve the optimum concentration in the treated water.

Ammonia

Ammonia in surface waters comes from the decomposition of organic matter, and in clean water rarely exceeds a few tenths of a

mg/l. Ammonia is a constituent of municipal sewage and of wastes from coke plants commonly included in steel mill operations.

A concentration of 2.5 mg/l of ammonia is considered to be harmful to fish if the pH of the water is in the range of 7.4 to 8.5. Toxicity decreases with decreasing pH. It has been found that concentrations of 1.5 mg/l or less are not harmful to most varieties of fish. Ammonia in the raw water of treatment plants requires compensating quantities of chlorine in plants where free residual chlorination, the most effective method of bacterial disinfection, is practiced. Each mg/l of ammonia requires about 8 mg/l of chlorine before a free chlorine residual can be obtained. This can cause a significant increase in the cost of water treatment.

Data on ammonia in the Mahoning River at Lowellville are available in the U. S. Geological Survey Records for the water years (October through September) 1958, 1959, and 1960. The annual average concentrations of ammonia (as NH_3) are remarkably constant, at 3.3, 3.3, and 3.2 mg/l. Individual values, however, frequently have been in the range of 6.0 to 8.0 mg/l. Such concentrations almost certainly would destroy any fish that might be present in the Mahoning. Even after dilution with the Shenango River to form the Beaver, the resulting concentrations of ammonia probably would be harmful to fish.

Although no data on ammonia at the Beaver Falls water intake are available, it is certain that ammonia concentrations sufficiently high to add significantly to the chlorine requirements of water treatment persist to the intake.

Cyanides

Cyanides in water are toxic to fish in low concentrations. Cyanides are included in the wastes from coke plants and, therefore, frequently occur in steel mill wastes. Cyanides also are used extensively in metal plating operations.

The Aquatic Life Advisory Committee of the Ohio River Valley Water Sanitation Commission recommended that free cyanide in excess of 0.025 mg/l be considered unsafe in the Ohio River. In the Mahoning River, which has low D.O. and pH, and relatively high ammonia, all of which increase the toxicity of cyanides, a given concentration of cyanide would be expected to be even more toxic than the same concentration in the Ohio.

Few data on cyanides in the Mahoning River have been found. The results of 15 determinations on the river at Lowellville during the period of November 1952 through September 1953 have been reported by ORSANCO. The values ranged from 0 in one-third of the samples to as high as 1.0 mg/l. The average of all results was 0.25 mg/l, which is 10 times the recommended limit. All 10 of the positive results exceed the limit by factors of 4 to 40 times.

Some of the cyanide concentrations reported at Lowellville in 1952-1953 would have been lethal to any fish that might have been in the river at that time. There is no known reason to assume that cyanide wastes have been reduced significantly since that time.

There is no evidence that cyanides have occurred in the raw water at Beaver Falls in concentrations sufficient to be harmful to consumers of the water supply.

Visual Evidences of Pollution

During the week of January 4, 1965, Public Health Service personnel observed the Mahoning, Shenango, and Beaver rivers at numerous points in connection with the collection of stream samples.

From Warren, Ohio, to the mouth of the Mahoning, from Sharon, Pennsylvania, to the mouth of the Shenango, and from the confluence of these two streams, the surfaces of the three streams were covered with an oily film.

Along the Mahoning River black, oily sludge lined the banks, and masses of these materials hung from bushes and tree limbs near the water's edge.

In and below the Youngstown area, gobs of dark, greasy material bobbed up and down in the water as they moved along with the current.

The scenic values of the Mahoning River below Warren have been destroyed, and those of the Shenango and Beaver seriously damaged.

AQUATIC LIFE

Environments in which aquatic organisms live are often changed by man-produced pollution. These changes are reflected in the kinds and numbers of aquatic plant and animal life that may persist. Unpolluted water courses support many kinds of clean-water-associated bottom organisms such as stoneflies, mayflies, caddisflies and alderflies. Pollution-tolerant forms such as certain leeches and sludgeworms may be present in unpolluted water, but usually are few in numbers. Stream conditions that permit the development of an assemblage of clean-water-associated organisms provide food for fishes and prevent development of nuisance organisms in large numbers.

Responses of aquatic organisms to domestic and industrial wastes depend largely on the amounts and kinds of such materials entering their environments. One response is manifest by the loss of a few kinds of organisms that thrive only in clean water environments, while those that may be associated with mildly polluted waters increase slightly in numbers. A more drastic response involves the disappearance of all clean-water-associated forms and the development of pollution-tolerant organisms often associated with sludges and slimes. Yet another response is associated with environments that are toxic to certain organisms and in which there is a substantial reduction in numbers of most forms and an elimination of many. In severely toxic environments, no organisms exist.

A biological survey to evaluate bottom organism populations in the Mahoning, Beaver, and Shenango rivers was made during the week of January 4, 1965.

Bottom organisms were reduced in numbers from over 2,000 per square foot upstream from Newton Falls, Ohio, to about 350 per square foot upstream and downstream from Warren, 300 per square foot at Lowellville, and 850 per square foot at the first bridge crossing downstream from the Ohio-Pennsylvania State line (Table 9, Figures V and VI). Similarly, 9 and 11 different general kinds of organisms were found in the West Branch and East Branch, respectively, upstream from Newton Falls. Only one kind, a pollution-tolerant organism, was found at Lowellville, and 3 kinds were found at the first bridge crossing downstream from the State line. Although few in numbers downstream from Newton Falls, clean-water-associated organisms were found downstream to the highway 422 bridge upstream from Warren, Ohio. Clean-water-associated organisms were not found throughout the remainder of the Mahoning River. Only pollution-tolerant sludgeworms persisted at Lowellville, and only pollution-tolerant sludgeworms and leeches and one kind of tolerant snail were found at the next station downstream of the State line. The absence of clean-water-associated fish food organisms in the Mahoning River downstream from Warren, Ohio, the severe decrease in the diversity of bottom organisms, and the decrease in the bottom organism population attests to the severely polluted condition of the river from Warren, Ohio, to its confluence with the Shenango River in Pennsylvania.

Table 9

Mahoning, Shenango, and Beaver Rivers
Bottom Organisms per Square Foot
January 1965

	Mahoning River											Beaver River				Shenango River			
Mileage / Organisms	West Branch Upstream fr. Newton Falls M-55.3-3.5	East Branch Pricetown 61.3	Rt 5 47.4	Park Rd. 43.2	Downstream fr. Power Dam 41.5	Rt 422 39.5	Upstream fr. Niles 31.3	Girard 23.6	Lowellville 11.4	Downstream fr. State Line 9.4	Rt 18-108 2.0	Rt 168 18.0	Wampum 14.0	New Brighton 2.0	1 mile Upstream fr. Ohio River 1.0	Upstream fr. Sharpsville 26.0	Rt 718 22.0	Upstream fr. New Castle 5.0	Downstream fr. New Castle 3.0
Stoneflies	*	-	-	-	-	-	-	-	-	-	-	-	-	*	-	5	-	-	-
Mayflies	*	10	-	-	-	-	-	-	-	-	-	-	-	-	-	26	-	-	-
Caddisflies	*	1374	1	2	4	3	-	-	-	-	-	-	-	-	-	408	-	-	-
Alderflies	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-
Riffle Beetles	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	71	-	-	-
Crane flies	*	-	-	-	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Snipeflies	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Black Flies	*	74	-	-	1	1	-	-	-	-	-	-	-	2	-	85	-	-	-
Scuds	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Limpets	-	20	-	-	-	-	-	-	-	-	-	18	-	2	-	5	-	-	-
Roundworms	*	1	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Snails	*	3	-	-	-	-	-	3	-	5	2	38	20	-	-	-	7	-	-
Fingernail Clams	-	31	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Midges	*	548	1	3	1	57	-	-	-	-	-	-	-	31	-	493	-	-	3
Leeches	-	1	-	-	-	-	-	3	-	4	56	7	3	-	-	-	20	-	-
Sludgeworms	-	18	22	15	1	289	323	3	294	850	5	1	-	114	132	-	90	66	2
Total Kinds	9	11	3	4	6	6	1	3	1	3	3	4	2	5	1	7	3	1	2
Total Per Sq. Foot	-	2081	24	21	10	354	323	9	294	859	63	64	23	150	132	1093	117	66	5

* Appeared in qualitative sample only; counted as one in totals.

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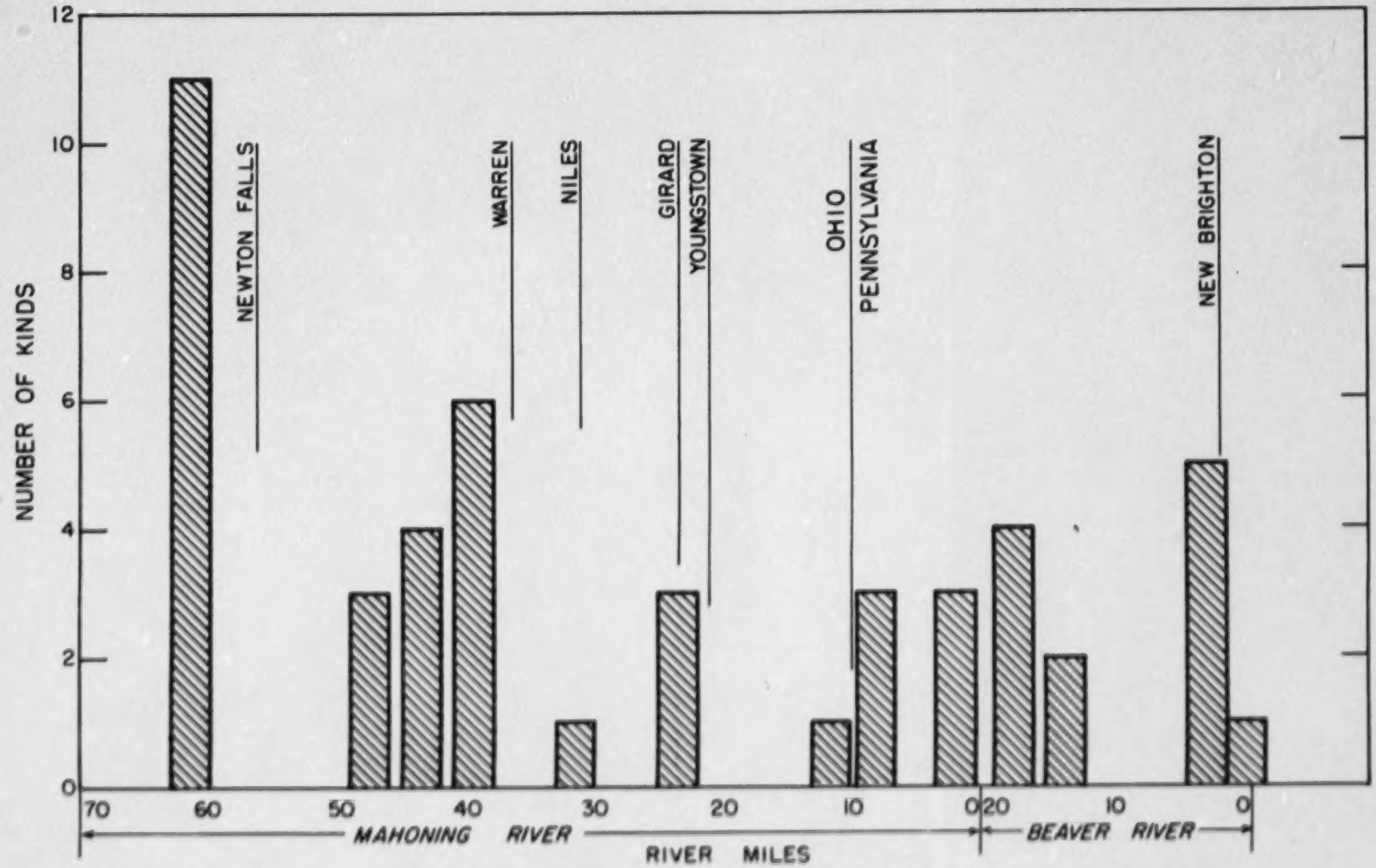
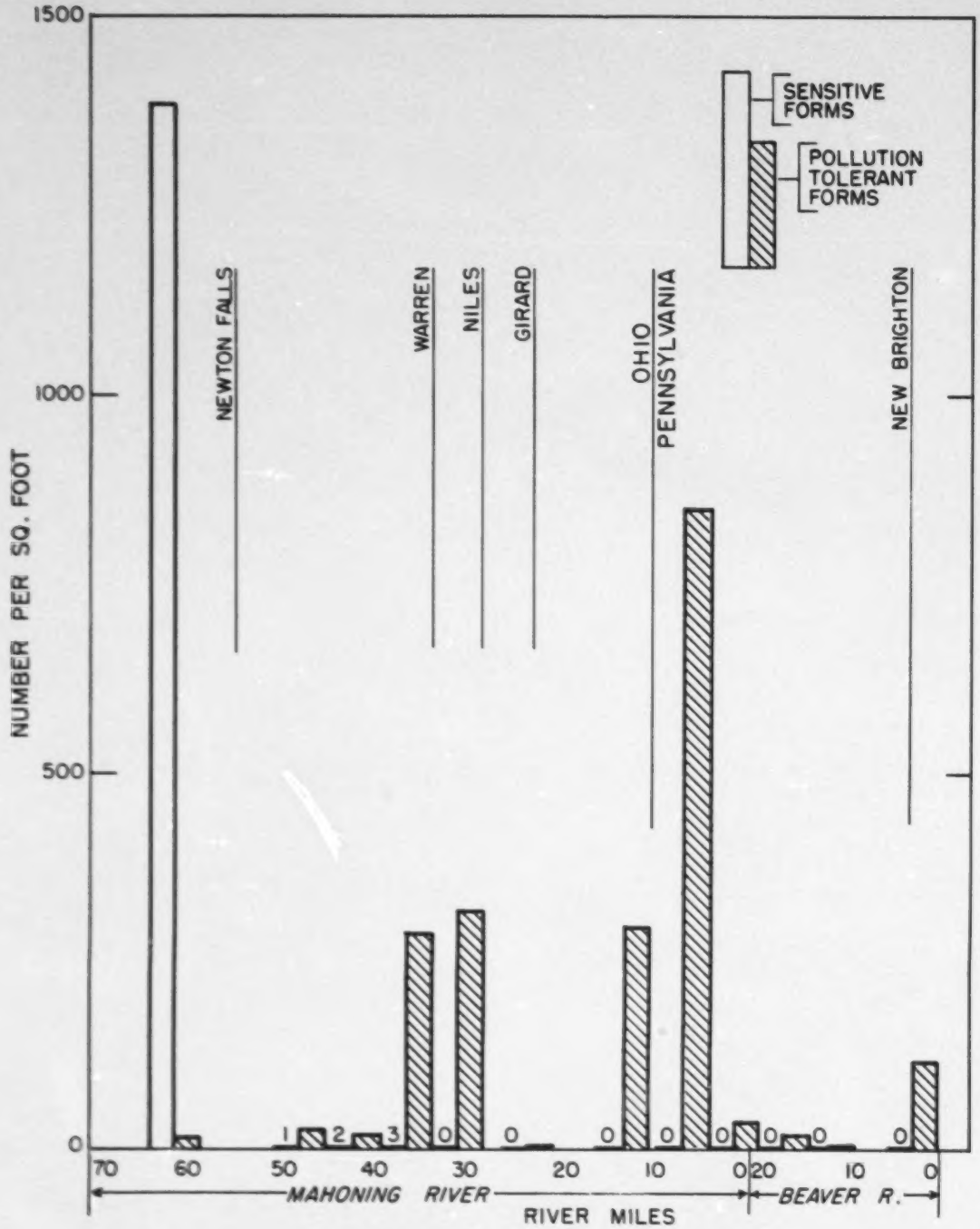


MAHONING - BEAVER RIVERS
KINDS OF BOTTOM ORGANISMS
JANUARY 1965

FIGURE V



MAHONING - BEAVER RIVERS
BOTTOM ORGANISM DATA
JANUARY 1965

FIGURE VI

The bottom of the Mahoning River throughout the reach studied was generally rock and rubble with sludge along the shores and in many slack water areas. Such a rubble substrate would be expected to support a bountiful fish food organism population, if not polluted. In many areas, oil formed a film on the water's surface, adhered to twigs, shoreline grasses and debris, and became mixed with the sludges. Substrate rocks and rubble were covered with a thick iron deposit that was harmful to bottom organisms in the Lowellville-State line reach.

Conditions of existence were only slightly improved in the Beaver River. Sludgeworm populations were reduced from those found in the more polluted reaches of the Mahoning River indicating a reduction in the organic food supply. At New Brighton, Pennsylvania, partial stream recovery was found. The different kinds of organisms had increased and stoneflies were observed in small numbers on rocks in the shallow water near the shore. These were not found in quantitative samples taken from deeper water where the impact of pollution would be expected to be greatest.

Oil was also found throughout the Beaver River. Many of the bottom rocks were red in color and showed evidence of an iron precipitate. Colonizing the rock's surface in shallower waters was a growth of slick, slimy algae often characteristic of polluted water.

Fisheries investigators have reported that the Mahoning River does not support a catchable fish population downstream from Warren, Ohio, to its confluence with the Shenango River, and that the Beaver River supports a catchable fish population only in its lower reach in

the New Brighton area. This was substantiated by an examination of the bottom organism population. In those areas where fishing was not reported, there were no bottom organisms on which fish normally feed.

The Shenango River was examined from the reach near the Sharpsville, Pennsylvania, water plant to its confluence with the Mahoning River (Table 9). Downstream from Sharon, few bottom organisms were found and conditions of existence for the bottom forms were similar to those observed on the Mahoning River.

Results of an examination of the phytoplankton population (drifting algae) were similar to those found for the bottom organism population. Values of total counts in the East and West Forks of the Mahoning River upstream from Newton Falls, Ohio, were in a range that would be expected in an unpolluted stream during the winter months (Table 10, Figure VII). Downstream from the U. S. Hwy. 5 bridge (mile 47.4) total count values were substantially depressed and remained depressed throughout the remainder of the Mahoning River. At Lowellville, Ohio, and at the first bridge crossing downstream from the Ohio-Pennsylvania State line, total count values were one-fourth of those upstream of Newton Falls. Some recovery was found at the highway 18 bridge upstream from the confluence of the Mahoning River with the Shenango River. Depressed algal counts demonstrate the degrading effect of pollution on this primary food source for aquatic life in the stream. The low phytoplankton total count values and the low population numbers found in the bottom organism population is strongly suggestive of the action of a toxic substance or substances to aquatic life.

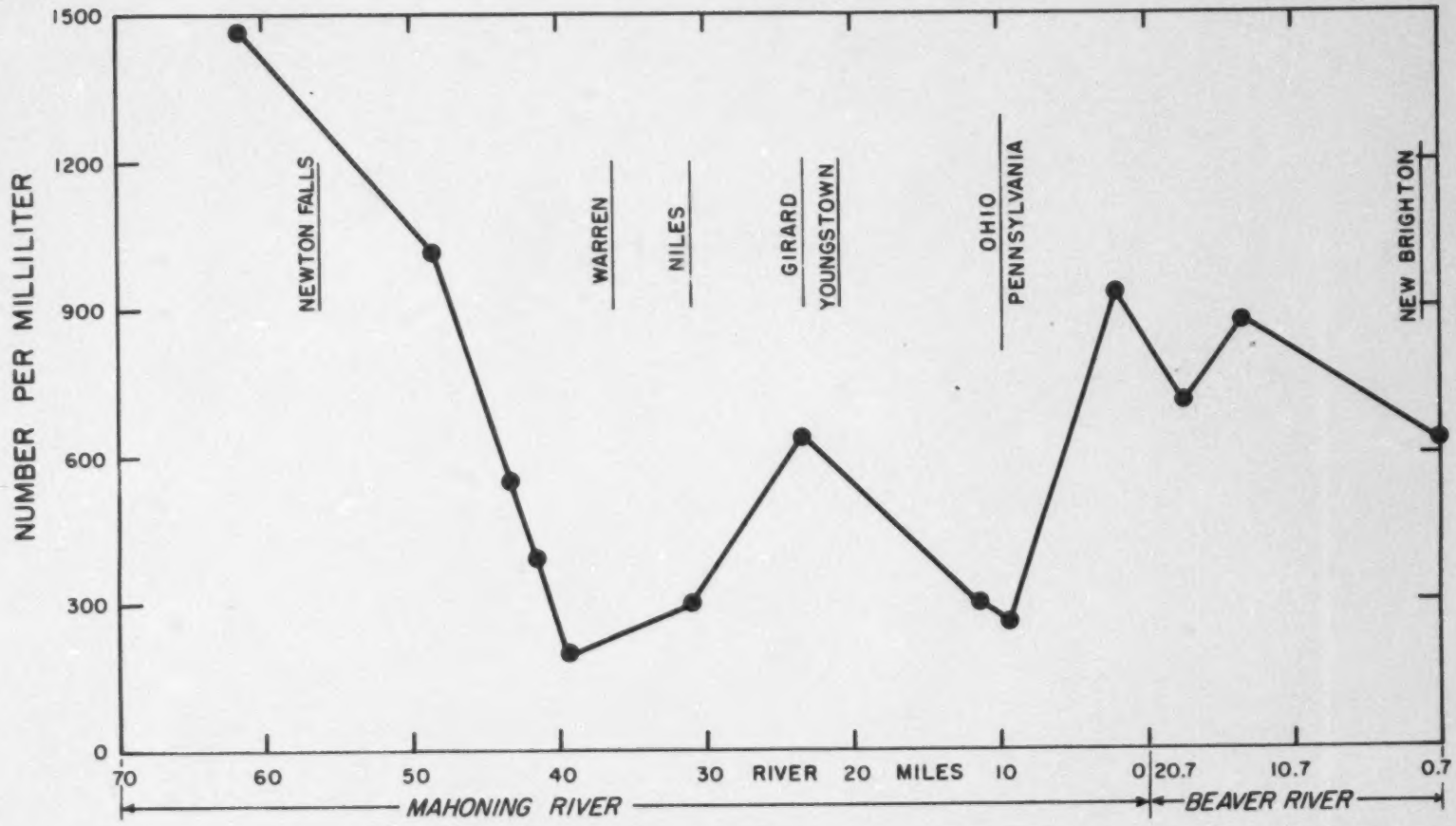
TABLE 10

MAHONING-BEAVER AND SHENANGO RIVERS

PHYTOPLANKTON DATA

TOTAL NUMBERS PER MILLILITER

STATION	DESCRIPTION	RIVER MILE	TOTAL/ml
East Fk. Mahoning R.	Pricetown Bridge	61.3	1,450
West Fk. Mahoning R.	Upstream from Newton Falls, Ohio	55.3-3.5	1,300
Mahoning R.	U. S. Hwy 5 Bridge	47.4	1,050
	Park Road Crossing	43.2	550
	Downstream from Power Dam	41.5	400
	U. S. Hwy 422 Bridge	39.5	200
	Upstream from Niles	31.3	300
	Girard	23.6	650
	Lowellville	11.4	300
	Ohio-Pennsylvania State line	10.4	
	1st Bridge downstream from State Line	9.4	250
	Hwy 18 & 108	2.0	950
Beaver R.	U. S. Hwy 168	18.0	700
	Wampum, Pennsylvania	14.0	850
	1 mile upstream from confluence with Ohio River	1.0	650
Shenango R.	Upstream from Sharpsville	26.0	1,350
	Hwy 718	22.0	400
	Upstream from New Castle	5.0	800
	Downstream from New Castle	3.0	350



MAHONING - BEAVER RIVERS

TOTAL PHYTOPLANKTON PER MILLILITER

FIGURE VII

46-R

Phytoplankton total count values were likewise depressed in the Beaver River, but were higher than those in the severely polluted reach of the Mahoning River.

In the Shenango River upstream from Sharpsville, Pennsylvania, phytoplankton counts were comparable to those found in unpolluted reaches of the Mahoning River (Figure VIII). Downstream from Sharon, counts were severely depressed. Some recovery was found upstream from New Castle, but wastes from New Castle reduced the counts just prior to the confluence of the Shenango River with the Mahoning River.

In general, the absence of clean-water-associated fish food organisms in the Mahoning River, downstream from Warren, Ohio, the severe decrease in the diversity of bottom organisms, and the decrease in the total bottom organism population attests to the severely polluted condition of the river from Warren, Ohio, to its confluence with the Shenango River in Pennsylvania. Conditions of existence were only slightly improved in the Beaver River although partial stream recovery was found at New Brighton, Pennsylvania. Results of the examination of the phytoplankton population were similar to those found for the bottom organism population. Where low phytoplankton total count values and low population numbers in the bottom organism population were found, it is strongly suggestive of the action of a toxic substance or substances to aquatic life. The production of a fish population in the polluted reaches of the Mahoning and Beaver Rivers would be affected similarly to the bottom organismand plankton

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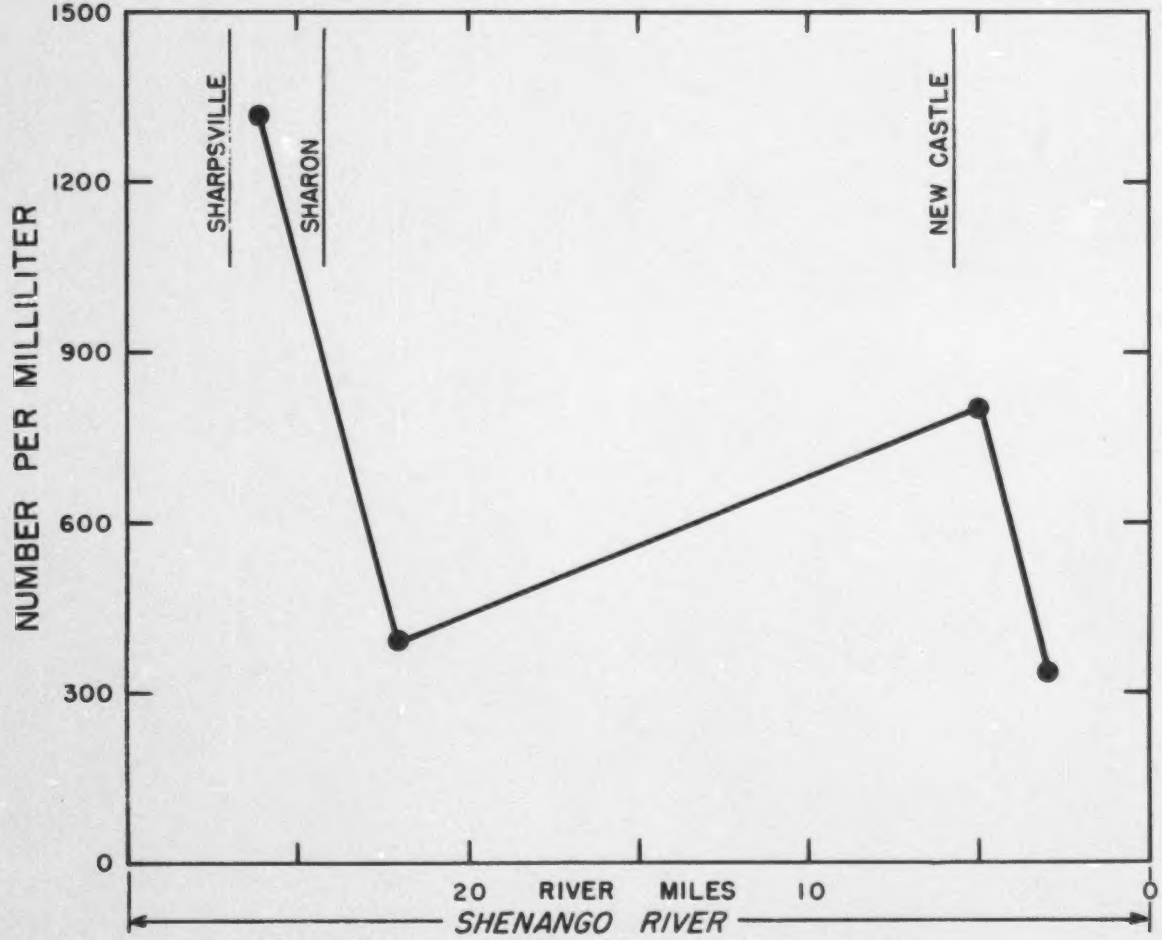

SHENANGO RIVER PHYTOPLANKTON
TOTAL NUMBERS PER MILLILITER

FIGURE VIII

populations. Fish production would be severely curtailed or eliminated from Warren, Ohio, on the Mahoning River to its confluence with the Shenango River, and on the Beaver River downstream to the New Brighton, Pennsylvania, area.

Municipal Water Treatment at Beaver Falls

The Beaver Falls Municipal Authority operates the Eastvale and New Brighton water plants which treat water taken from the Beaver River. These plants jointly supply water to the City of Beaver Falls, 9 boroughs and 6 townships. The population served is estimated to be 65,000.

The Eastvale plant, records from which are analyzed in this report, is located in Beaver Falls a few miles upstream from the New Brighton plant. The Eastvale plant was constructed in 1922. In 1957 and 1958, a new chemical house with chemical handling and feed equipment, new flocculation and settling tanks providing for two-stage coagulation and settling, and new filters were added. Present rated capacity is 8 mgd.

Raw Water Quality

The Beaver River is the source of the water treated at the Eastvale and New Brighton plants. Raw water quality data from the 1964 Eastvale Filter Plant operation reports are summarized in Table 7.

The coliform bacterial density, which is a measure of sewage pollution, averaged 31,000/100 ml. This is the same order of magnitude as found for this water source in a study conducted by the Public Health Service during 1954-1956. That study reports data from

54 water plants, which were carefully selected in an effort to include all plants treating water grossly polluted with sewage and having adequate data for the study. When these plants were coded in order of decreasing annual average coliform bacterial density in their raw water, the Eastvale plant was number 14. Only 13 of these 54 plants treated waters more heavily polluted with sewage insofar as indicated by the annual coliform densities.

The threshold odor numbers, which are reported to be estimated values, ranged from 20 to 200. Addition of one-fourth teaspoonful of water having a threshold odor of 200 to a cup of odorless hot water would result in detectable odor. These odors are described in plant records by such notations as D (disagreeable),* M (musty), E (earthy), Ch (hydrocarbon), stale, tar, and Ds (septic).

The concentration of iron averaged 0.87 mg/l, with high values of 5 and 50 mg/l being recorded for individual analyses. The manganese concentration averaged 0.39 mg/l with individual analyses of 0.80 or more mg/l in each of 6 of the 12 months.

Both iron and manganese are highly objectionable constituents in a municipal water supply. The domestic consumer complains of the brownish color that they impart to laundered goods, and of the impairment of taste of beverages, including coffee and tea. Many commercial and industrial processes are affected adversely by the iron and manganese content of water.

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* It is assumed that the coding describing the odors is that given in Standard Methods, 11th Edition.

The average hardness of the water was 184 mg/l.

The Ohio River Valley Water Sanitation Commission's study of the Beaver River at Eastvale during July 20 to December 7, 1959, showed phenol concentrations ranging from 0 to 35 mg/l and fluoride concentrations ranging from 0.2 to 0.7 mg/l.

The gross and variable pollution present in the Beaver River at the Eastvale intake shows that abnormal treatment measures are required to produce a safe and palatable municipal water supply.

Water Treatment

The Eastvale plant has facilities for two-stage coagulation and settling, for rapid sand filtration and for handling and feeding alum, lime, chlorine, chlorine dioxide, potassium permanganate and activated carbon. The treatment process is varied as considered desirable to provide adequate purification, including removal of iron, manganese and obnoxious taste and odor. Throughout 3 to 5 months of the year chlorination to provide free residual chlorine in the treated water is practiced. When free residual chlorination is not practiced, extensive use is made of chlorine dioxide, potassium permanganate and activated carbon, chemicals which ordinarily are not used at plants treating a good quality raw water. Chemical applications during 1964 are summarized in Table 11. Chlorination records at this plant are particularly interesting.

Table 11

Chemical Applications in Treatment of Water, 1964
Eastvale Plant, Beaver Falls Municipal Authority

Month		Water Treated mgd	Pound/mg					
			Alum	Lime	Chlorine	Sodium Chlorite	Activated Carbon	Potassium Permanganate
Jan.	Ave.	4.25	133	103	22.8	1.4	19.6	1.1
	Max.	5.24	201	124	25.7	2.5	32.7	2.0
	Min.	3.28	66	92	15.4	0.0	15.2	0.9
Feb.	Ave.	3.81	108	83	14.1	0.8	18.1	1.1
	Max.	4.59	167	104	19.2	3.1	35.8	1.4
	Min.	2.95	72	73	12.9	0.0	0.0	1.0
March	Ave.	4.09	211	122	41.1	0.8	13.8	0.9
	Max.	5.75	541	165	76.9	2.1	38.5	2.9
	Min.	2.73	90	75	14.7	0.0	0.0	0.0
April	Ave.	3.63	177	131	57.4	0.0	0.0	0.0
	Max.	4.42	358	210	93.6	0.0	0.0	0.0
	Min.	2.86	86	99	34.0	0.0	0.0	0.0
May	Ave.	3.74	176	162	79.9	0.0	0.0	0.0
	Max.	4.94	276	222	145.4	0.0	0.0	0.0
	Min.	2.84	82	106	44.6	0.0	0.0	0.0
June	Ave.	4.03	181	145	68.4	0.0	0.0	0.0
	Max.	5.38	442	333	220.2	0.0	0.0	0.0
	Min.	2.46	110	71	37.6	0.0	0.0	0.0
July	Ave.	4.04	155	216	123.1	0.0	10.9	0.0
	Max.	4.82	207	337	221.4	0.0	36.2	0.0
	Min.	2.90	90	92	29.3	0.0	0.0	0.0
Aug.	Ave.	3.83	128	293	164.8	0.0	0.0	0.0
	Max.	4.37	184	450	267.2	0.0	0.0	0.0
	Min.	2.19	79	174	95.8	0.0	0.0	0.0
Sept.	Ave.	4.01	102	327	200.0	0.2	5.5	0.2
	Max.	5.02	133	573	506.8	1.4	27.7	1.3
	Min.	3.16	52	96	38.2	0.0	0.0	0.0
Oct.	Ave.	3.77	119	139	38.3	1.2	22.8	1.3
	Max.	4.71	213	200	48.8	1.8	31.7	1.8
	Min.	3.31	77	117	29.6	0.0	0.0	0.9
Nov.	Ave.	3.62	168	149	32.3	0.0	0.0	1.4
	Max.	4.17	367	198	44.6	0.0	0.0	1.9
	Min.	3.12	110	124	26.5	0.0	0.0	1.1
Dec.	Ave.	3.76	170	118	25.3	0.0	0.0	1.4
	Max.	4.42	292	160	30.3	0.0	0.0	1.8
	Min.	2.94	100	93	23.1	0.0	0.0	1.1

Chlorination of water is used primarily to kill bacteria and other infectious organisms. At the Eastvale plant it is used also to reduce taste and odor and to precipitate iron and manganese.

The amount of chlorine required to treat a water is one measure of its pollution. The average annual chlorine applications, which were 8.9, 8.0, and 8.6, for the years 1964, 1963, and 1962, indicate gross pollution of the source water. The chlorine requirements at the Eastvale plant are compared with those at 20 water plants treating some of the most grossly polluted waters in the United States. Table 12, tabulates, in order of decreasing chlorine applications, data from the 1954-1956 Public Health Service study of 54 water plants carefully selected to include those treating grossly polluted waters. Plant 1 applied the greatest amount of chlorine, 14.5 mg/l. It produced water containing 5 mg/l of chlorine, which was used only for industrial cleaning operations. Plant 2 applied 11.4 mg/l of chlorine and plant 3 was able to practice free residual chlorination with applications of 9.6 mg/l. Only 3 of these 20 plants applied chlorine dosages greater than the 8.9 mg/l required at the Eastvale plant in 1964. Although some of these water plants presently may be using greater chlorine applications, those at the Eastvale plant are among the highest used at water plants in the United States. Still more chlorine would be required if the Eastvale plant continuously practiced free residual chlorination. During a 154 days of such operation in

Table 12

Chlorine Application at Water Plants Treating Grossly Polluted Water
(In order of decreasing magnitude)

Plant No.	Years of Record	Average Chlorine Application, mg/l	Comments
1	2	14.5	Industrial supply, total chlorine residual averaged 5 mg/l.
2	2	11.4	
3	2	9.6	Free residual chlorination
Eastvale	1	8.9	(1964) See Footnote
Eastvale	1	8.6	(1962)
4	2	8.4	Free residual chlorination
5	2	8.2	
Eastvale	1	8.0	(1963) See Footnote
6	2	7.9	
7	2	7.1	
8	2	7.0	
9	2	6.6	
10	2	6.4	
11	2	6.3	
12	2	5.9	
13	2	5.7	
14	2	5.3	
15	2	5.3	
16	2	5.2	
17	2	4.6	
18	2	4.6	
19	2	4.4	
20	2	4.3	

At the Eastvale Plant the average chlorine application for 154 days in 1964 during which free residual chlorination was practiced was 16.5 mg/l, and for 103 days in 1963, 22.1 mg/l.

1964, the chlorine requirement averaged 16.5 mg/l; and during the 103-day in 1963, it averaged 22.1 mg/l. Maximum daily chlorine applications of 60.7 and 43.3 mg/l occurred during 1964 and 1963, respectively. Given a good water source, free residual chlorination should be obtainable using annual average chlorine applications of only 3 or 4 mg/l, with maximum daily applications about 6 to 8 mg/l. The operation reports show substantial increases of chlorine applications occur from one day to the next. Rapid and sudden increases in chlorine needs in excess of 10 mg/l require more than normal care to insure adequate disinfection.

The orthotolidine colorimetric test for residual chlorine is used at the Eastvale plant to measure combined residual chlorine in the treated water throughout approximately 8 months each year. If iron or manganic manganese are present in the treated water in amounts exceeding 0.3 mg/l and 0.01 mg/l, respectively, the development of the yellow color upon addition of the orthotolidine cannot be accepted as being due to chlorine alone. Unless allowances are made for such false test results, the plant operator may be mislead into believing adequate disinfection of the water has been accomplished.

Chemical costs per million gallons of water treated are given in Table 13. This table also shows the estimated costs attributed to pollution. For the period 1962 through 1964, this extra chemical cost averages $4.30 per million gallons, and if applied to 2 billion gallons

Table 13

Chemical Costs per Million Gallons of Water Treated
Eastvale Plant, Beaver Falls Municipal Authority

Chemical	Costs* cents/pound	Year 1962	1963	1964
Alum	2.36	3.94	4.38	3.62
Lime	0.93	1.44	1.56	1.54
Chlorine	4.92	3.54	3.12	3.64
Chlorite	53.	0.41	0.26	0.20
Carbon	7.98	1.57	1.35	0.62
Potassium Permanganate	27.84	0.24	1.60	1.65
Chemical cost $/mg		11.14	12.27	11.27
Cost of Chlorite, Carbon, Pottasium Permanganate		2.22	3.41	2.47
Cost of Chlorine for application above 4 mg/l or $1.62/mg		1.92	1.50	2.02
Cost of chemicals due to poor quality water		4.14	4.91	4.49

*Current costs as given by S. P. McBride, January 20, 1965

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per year of water treated by the two plants operated by the Beaver Falls Municipal Authority, it would amount to $9,000 annually.

Quality of Treated Water

Data presented in the Eastvale Filter Plant operation reports show that in spite of the grossly polluted water source, the plant produced a treated water (at plant outlet) in which no coliform bacteria were detected, free from turbidity, practically free from color, and having an iron content below the limiting concentration considered acceptable for municipal water supplies by the Public Health Service Drinking Water Standards. (See Table 14.)

Manganese concentrations in excess of 0.05 mg/l, which is the maximum concentration considered acceptable in good public water supplies, was reported for 33 days during 1964. Monthly average concentrations were 0.06 mg/l during June and July.

Manganese is an objectional constituent in a public water supply. It stains plumbing fixtures, imparts a brownish color in laundered goods and impairs the taste of coffee and tea. Many commercial and industrial processes are affected adversely by the manganese content of water.

Threshold odor, which is reported to be estimated, exceeded the recommended value of 3, but only on 11 days during 1964.

An undesirable characteristic of this water is its hardness, which has increased with time as shown in Figure IX. At least part of this increase is the result of pollution resulting from sewage, industrial wastes and other sources.

Table 14

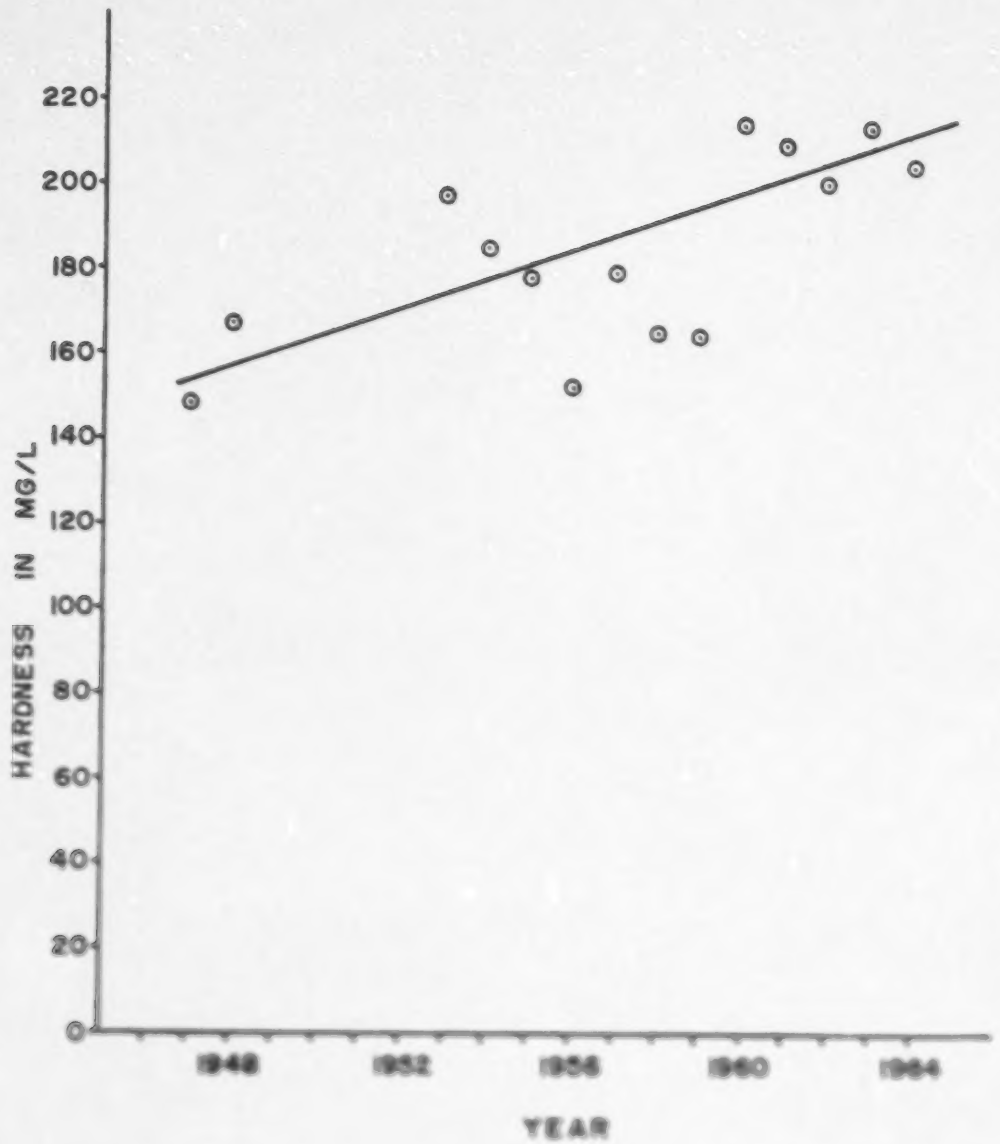
Quality of Treated Water at Plant
Eastvale Plant, Beaver Falls Municipal Authority

1960		Alkalinity as $CaCO_3$, mg/l	Acidity as $CaCO_3$, mg/l	Turbidity	Color	pH	Odor	Hardness as $CaCO_3$, mg/l	Iron mg/l	Manganese mg/l	Chlorine Residual mg/l	Coliform Bacteria per 100 ml P.T.
	Ave.	56	3	0	.4	7.5	-	215	.03	0.03	1.3	0
Jan.	Max.	82	5	0	3	7.6	3	264	.08	.20	1.5	0
	Min.	30	2	0	0	7.5	2	140	.0	.00	0.8	0
	Ave.	50	3	0	.7	7.5	-	210	.03	.01	0.8	0
Feb.	Max.	73	4	0	3	7.6	2	238	.05	.10	0.8	0
	Min.	30	3	0	0	7.4	2	174	.0	.00	0.8	0
	Ave.	38	2	0	.6	7.5	-	158	.03	.03	0.8	0
Mar.	Max.	68	4	0	3	7.6	3	246	.05	.20	1.2	0
	Min.	20	1	0	0	7.2	2	100	.01	.00	0.5	0
	Ave.	37	1	0	0	7.5	-	145	.03	.00	0.6	0
Apr.	Max.	48	3	0	0	7.8	2	182	.08	.00	0.7	0
	Min.	25	0	0	0	7.3	2	128	.01	.00	0.4	0
	Ave.	44	2	0	.5	7.5	-	172	.07	.00	0.6	0
May	Max.	56	4	0	2	7.6	4	216	.15	.05	1.0	0
	Min.	35	1	0	0	7.3	2	132	.03	.00	0.5	0
	Ave.	50	3	0	1	7.5	-	210	.09	.06	1.0	0
June	Max.	57	4	0	3	7.8	4	234	.16	.20	1.3	0
	Min.	16	1	0	0	7.5	2	182	.02	.00	0.5	0
	Ave.	45	3	0	1	7.5	-	218	.05	.06	1.3	0
July	Max.	56	5	0	4	7.6	4	232	.23	.20	1.5	0
	Min.	35	3	0	0	7.2	2	204	.02	.00	1.0	0
	Ave.	43	4	0	1	7.4	-	219	.06	.00	1.1	0
Aug.	Max.	57	6	0	2	7.6	4	252	.10	.00	1.5	0
	Min.	32	2	0	0	7.0	2	196	.03	.00	0.8	0
	Ave.	40	4	0	.9	7.3	-	253	.05	.00	1.7	0
Sept.	Max.	47	7	0	3	7.5	4	278	.15	.00	2.2	0
	Min.	26	2	0	0	7.0	2	218	.01	.00	1.0	0
	Ave.	40	2	0	.7	7.5	-	247	.03	.01	1.5	0
Oct.	Max.	47	4	0	2	7.7	3	262	.09	.23	1.7	0
	Min.	28	0	0	0	7.4	2	228	.00	.00	1.5	0
	Ave.	47	2	0	.1	7.5	-	234	.03	.00	1.5	0
Nov.	Max.	57	3	0	2	7.6	3	244	.08	.00	1.6	0
	Min.	37	1	0	0	7.2	2	220	.00	.00	1.5	0
	Ave.	43	2	0	0	7.6	-	179	.02	.01	1.5	0
Dec.	Max.	52	5	0	2	8.1	3	212	.05	.05	1.7	0
	Min.	33	0	0	0	7.5	2	150	.00	.00	1.2	0

54a

FIGURE IX

HARDNESS OF TREATED WATER
EASTVALE PLANT
BEAVER FALLS MUNICIPAL AUTHORITY



Hardness affects the consumer. Hard water results in increased use of soaps, synthetic detergents, general household cleansers, scouring compounds, and bleaches. An increase of 25 mg/l of hardness, which is considered to be a conservative estimate of that attributable to pollution, would result in increased purchases of soaps, synthetic detergents, etc., costing about 30 cents per person per year. The total increased cost to the 65,000 users of this water is approximately $20,000 per year.

Other intangible economic damages due to increased hardness of the water include increased fuel consumption due to scaling of boilers and hot water tanks, adverse effects on plumbing, and increased costs of additional treatment required by certain commercial establishments.

APPENDIX A

Statement by
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U. S. Department of Health, Education & Welfare
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APPENDIX A

Federal Reservoirs and Waste Treatment

At present, almost all of the communities from Warren, Ohio, downstream to the Ohio River provide only primary waste treatment. The provision of a higher level of waste treatment is needed. This need is pointed out in the Public Health Service report of October 1956, written for the Corps of Engineers in partial justification of West Branch Reservoir, now under construction, which states that, "...the analysis indicates a minimum dissolved oxygen content of 3.0 ppm could be maintained in the river during the summer months with the current flow schedule over the life of the reservoir, provided the organic waste load could be reduced by 85 percent before discharge to the river."

Streamflow regulation, provided by four Federal reservoirs in the Beaver River Basin, has been justified in large measure by benefits to water quality control. Current authority for crediting these benefits is found in P.L. 660-84th Congress as amended by Section 2(b)(1) which reads as follows: "In the survey or planning of any reservoir by the Corps of Engineers, Bureau of Reclamation, or other Federal agency, consideration shall be given to inclusion of storage for regulations of streamflow for the purpose of water quality control, except that any such storage and water releases shall not be provided as a substitute for adequate treatment or other methods of controlling waste at the source."

For the specific purpose of interpreting this law only, "adequate treatment" has been defined as at least 85 percent removal of BOD or the equivalent in the case of industrial wastes, or even higher degrees of treatment, should it be in practice in the area.